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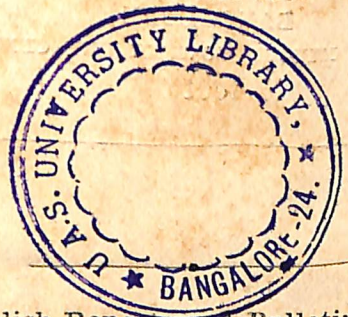
DEPARTMENT OF AGRICULTURE
MYSORE STATE.

SECOND ANNUAL REPORT

OF THE

AGRICULTURAL CHEMIST

FOR THE YEAR 1900-1901.



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Dec No 6099

SECOND ANNUAL REPORT OF THE AGRICULTURAL CHEMIST FOR 1900-1901.

During the past year 1900-1901, two Assistant Chemists have been transferred from the Geological Department to the Department of Agriculture. But with them the chemical work of the Geological Department, which these two assistants had been doing, was also transferred. The object was to concentrate the chemical work done by the State, and thus make the laboratory more serviceable than two smaller ones would have been and economise space and apparatus. This transfer also gave the Assistant Chemists that trained supervision in their analytical work which they were in need of, and helped them to economise time and increase the accuracy of their work. But, although the increase in the staff of the Department of Agriculture caused by the transfer of these two assistants is only a nominal one, an actual increase has taken place by the appointment of a Probationary Assistant Chemist. The man selected is the first M. A. graduate in Chemistry from the Madras University. Further assistance in chemistry will no doubt be granted when an opportunity offers. Some minor officials have also been transferred to the Department.

Without reflecting on the work of the other members of the Department, I should like to specially mention the names of Mr. B. Venkata Rao, B.A., Assistant Chemist, and K. V. Krishnasami Iyer, Chief Clerk, for the faithful work they have done since joining the Department of Agriculture.

Laboratory.

A part of the new Chemical Laboratory has been practically completed and in it the work has been carried on since February 1901. The piping, fitting and furnishing has been done by the Department of Agriculture, and although it has cost a very large amount of time and work and is not yet completed, it has been put in as economically as

possible, and no pains have been spared to make it the best that could be obtained. When finished, this laboratory will doubtlessly be one of the best in India. The additions erected by the Public Works Department have been roofed over and will, it is hoped, be ready for occupation in a few months.

Chemical Work.

As the fitting of the laboratory is not yet completed, work in it has been, as might be expected, more or less interrupted. Soils, sugars and the chemical work of the Geological Department have received most attention.

Soils.— Thirty-six samples of soils were taken for chemical analysis. Half of them from the proposed Experimental Farm at Hebbal. The others from the proposed experimental fields of various Coffee estates in the Hassan and Kadur Districts. As this work is not sufficiently advanced I cannot report on it at present.

Sugars.—Before beginning experimental work in sugars it was thought wise to analyse sugar-cane in various parts of the State to get an indication of its quality. Instead of sending the sugar-cane to the laboratory to be analysed, several tours with the necessary apparatus were made to various parts of the State. After beginning the analysis of sugar-cane, some of the jaggeries boiled from the analysed juice were also analysed with a view to ascertain the amount of loss taking place during boiling. This, as will be seen from Table I, is tremendous; and some preliminary work was done to ascertain how the losses occurred. They are largely due to two causes which can be easily remedied by the raiyat; and to one cause which is at present largely beyond his control. The two former are fermentation and insufficient liming of the juice. The latter is the inversion caused by over heating of the juice in the pan.

In all these cases sugar is decomposed into a substance called glucose, which prevents double its weight of sugar from crystallising out and is liable to make jaggery run in the monsoon. One pound of sugar when decomposed into glucose makes about a pound of this substance, so that for every pound of sugar decomposed really three pounds of sugar are lost,

Liming.—All sugar-cane juice contains acids. These acids gradually decompose sugar in the juice, especially when the latter is heated. By adding lime to the juice and filtering out the dirty white insoluble

substance it forms, we can get rid of these acids. This is the method generally employed in all sugar producing countries. But, even if we do not filter out this dirty white insoluble substance formed by the lime, which we will call salts of lime, the power of the acids to decompose sugar is lost. Unfortunately, the jaggery appears to get somewhat discoloured, if these salts of lime are left in the juice, and the jaggery is, of course, much more impure if they are left in than it would be if they were filtered out. Some experiments will be made on this point during the coming year, which, it is hoped, will further pave the way for producing jaggery of better quality. The quantity of the acids in the juice is not always the same. Therefore the quantity of lime which must be added to the juice to destroy the power of these acids to decompose sugar must vary. We must consequently have something to tell us when enough lime has been added. The experienced jaggery boiler tries to judge this from the appearance of the juice. A much more reliable way is to test it with red litmus paper ; and to add lime until this red litmus paper begins to turn blue. If less lime than this is added, some of the acid will be left to decompose sugar. If more lime is added, some of the sugar will become insoluble and will be lost when the juice is filtered, or the jaggery is refined unless it receives some special treatment beforehand.

The quantity of lime usually added by the raiyats varies very much. Some use barely sufficient to neutralize the acids in about $\frac{1}{6}$th of the juice they boil to jaggery. Others add nearly double this quantity. Some neutralize nearly half the juice before boiling it. And in two instances, I have found them using about sufficient lime to neutralize all the acids in the juice. But in these latter cases, though loss by insufficient liming was avoided, an almost equal amount of loss was caused by allowing the juice to ferment before beginning to boil. In the five samples of such jaggeries analysed, the loss varied from 9 per cent. to 21 per cent. Two of these, Nos. 145 and 147, are given in Table I. When fermentation was avoided and liming done as indicated by litmus paper, the results were very satisfactory. In this case, the loss caused by the increase of glucose amounted to only from 3 per cent. to 4 per cent. Jaggeries Nos. 135 and 159 in Table III represent about the average result. Juice No. 134, Table III, from which jaggery No. 135 was boiled, had unfortunately an exceptionally high percentage of glucose, so that, although comparatively little decomposition of sugar took place, the jaggery contains a very high percentage of glucose.

Fermentation.—The loss due to fermentation is probably quite as great as that due to underliming. And there is really no excuse for it. If the chatties are kept clean, and boiling is begun as soon as possible, there should be no fermentation even when milling is carried on during the hottest part of the day. Fermentation is caused by a microscopic plant growing in the juice. These multiply very fast, and in doing so, decompose the sugar. The warmer the juice, within certain limits, the more rapidly they grow and the more sugar they decompose. This heat and the consequent increase of fermentation accounts for jaggery No. 150 in Table II having such a high percentage of glucose compared with jaggery No. 152 which was made from the same lot of cane as No. 150 but milled in the cool part of the day. Frequently washing out with boiling water the chatties into which the juice is milled would probably help very materially in keeping down fermentation. But one of the chief aims should be to boil the juice as soon after it is milled as possible, as boiling kills these ferments. Of course, the time required for fermentation to begin, after the juice has been milled, will vary materially. If the juice is caught in a chatty which has a few drops of fermented juice in it, fermentation will doubtlessly begin at once, especially if the juice is warm. But if the vessel is clean, and the juice is cold, it may take some time before any appreciable loss from fermentation occurs. The percentages of glucose, as found in juice No. 153, Table II, at different times, indicates the latter, and the analysis of juice No. 144 compared with No. 146, Table II, points to the former.

Inversion by overheating.—Raiyats may, to some extent, avoid this loss by keeping their fires as small as possible. Boiling the juice by steam instead over a direct fire, will still further reduce this loss. But in order to avoid it as much as possible, vacuum pans are necessary, and as a matter of fact, vacuum pans and other improved machinery are used in all countries in which the sugar industry is flourishing.

In Northern India jaggery boiling is, I believe, further advanced than in Southern India. At least, the analysis of North Indian jaggeries, I have seen, showed much less glucose than those of the jaggeries usually met with in the southern portion of this vast country, and refineries naturally avoid the southern product and import from the north. This smaller quantity of glucose in the northern jaggeries is doubtlessly due to better liming and greater care to prevent fermentation. In some parts of Northern India the raiyats have also realized

the necessity of getting rid of some of the impurities (principally glucose) and instead of boiling down the juice, or better syrup, to such a consistency that it will solidify on cooling they stop short of this, allow the mass to cool, and after the grains of sugar have formed to their full extent, they separate the molasses by centrifugal machines. *Let us try to lime carefully to get rid of all the acids and some other impurities, filter out this muck, and separate the molasses from the sugar*, and we shall have done much to build up our sugar industry; especially if the much greater profits thus realized will be spent on further improvements, such as the building of sugar houses as found in the Hawayeen Islands, in Cuba (before the war), in Demarara, in Louisiana, and in nearly every other sugar producing country of note.

That a loss of 18 per cent of sugar on 100 lbs. of jaggery is, as stated before, tremendous every one, even in India, will, I think, admit. But it implies even more than appears on the surface. Taking for example jaggery No. 154, Table I, if no inversion had taken place the quantity of juice required to give us this particular jaggery would have given us about 76 lbs. of pure sugar; as it is, it only gives 58½ lbs. If these 58½ lbs can be sold for Rs. 5, the 76 lbs. would realize Rs 6-7-4, or a saving of Rs. 0-4-8 on every 16 annas. It should be quite easy to save at least ¾ of this loss; (in jaggery No. 159, Table III, ⅚ of the loss has been avoided). The saving of ¾ of the average loss would imply an extra Re. 0-3-6 on every rupee without probably costing an extra pie. Quite apart from this is the higher price which would be paid for the better *quality* of jaggery produced. For the above Re. 0-3-6 only refer to the extra *amount* of sugar produced and not to the better quality, which the higher grade of jaggery would imply. This would probably more than equal the above Re. 0-3-6. But I shall not enter into a discussion on that subject at present.

In Table IV are given several analyses of some varieties of cane generally grown in Mysore. The most popular is the ordinary striped cane, and justly so, so far as its composition is concerned. (I shall not give descriptions of varieties at present.) In column 7, the relative value of the different varieties (so far as composition goes) can be seen at a glance. This composition is very satisfactory. The cane grown in Louisiana possibly marks the lowest limit at which cane can pay the cost of growing and manufacturing it. There cane seldom, if ever reaches the lowest sugar content given in our tables, and to say that the average would probably be 12 per cent. is placing the figure high. The

glucose in Louisiana cane is on the other hand very much higher than that given in the annexed tables as it seldom drops below 1 per cent. With us the average percentage of sugar, as judged from Table III, is nearly 20 per cent, and the glucose is not much more than half a per cent, so that in both respects the Mysore cane is vastly superior to this minimum.

The fatal results of cutting cane when not mature, may be judged when comparing No. 103 and No. 102 in Table III. The latter, which is cut long before being mature, is absolutely useless for sugar making. Its juice will yield only a syrup. But if allowed to ripen, it would have given a very good turn out of sugar. Its total solids are higher than that of any other cane analysed during the year. Even No. 103 which is said to have been eighteen months old is apparently not ripe, as it contains quite 2 per cent. of glucose or nearly double that of any other cane (excepting No. 102) found in the Table.

From the preceding, we learn that we have to be very careful—

(*a*) to lime the juice to neutrality as indicated by litmus,

(*b*) to prevent fermentation by keeping everything as clean as possible, and losing no time in beginning to boil the juice,

(*c*) not to cut the cane before it is mature, and

(*d*) to boil with as small a fire as possible.

By observing these factors, the raiyats, as a whole, will save at least four annas on every rupee. The losses in milling, in cultivating and in manuring the cane will be considered at some future time.

Jaggery versus *Raw Sugar*.—So long as jaggery boiling is continued, it is, of course, necessary to make it as profitable as possible for the raiyats engaged in it. But the aim should be to replace this method of utilizing the sugar-cane as soon as possible by a rational system of sugar making.

No doubt, there will remain in India a market for jaggery for generations to come. But this market will no doubt continue to grow smaller and smaller, while the market for the various forms of sugar will continually increase. If this be the case, it is evident that if India is to retain the position it holds at present, it must increase its supply of sugar at the expense of jaggery. To do this by refining jaggery is certainly a wasteful method ; because—

(*a*) In jaggeries numerous impurities are retained which could be

easily removed if the juice were boiled into raw sugars, but are more difficult to remove later on.

(*b*) The better grades of raw sugar would be equal to the poorer grades of refined sugar in the market at present, (as a matter of fact, sugar can be made directly from the juice without bone char equal to the best grades of refined sugar. And such sugar is being made in America). The cost of refining such sugars will therefore be saved.

(*c*) It is cheaper and easier to refine such raw sugars as may require refining than to refine the average jaggeries, and this saving will more than compensate for the extra expense in making the raw sugars.

In order to retain the present extent of cane cultivation, it is therefore better to boil the juice directly into sugar than into jaggery as done at present.

It is, however, a low ambition to simply retain the present position of the sugar industry, when India is importing sugar on such a large scale as it does. Deducting the exports from the imports for the past year, there remains a net import of sugar to the extent of over 130,000 tons. In other words, it would take a railway train covering over 35 miles of track car touching car, to carry this sugar, or one train composed of 24 car-loads of sugar would have to run every day of the year to take away the sugar from the steamships as they come in.

This import takes place into a country which may be considered as the original home of the sugar industry; into a country which possesses, in some respect at least, great advantages for the production of sugar over the countries from which the sugar is imported. India ought certainly to be able to produce this sugar at home. But if it is necessary to partially abandon jaggery boiling in favour of raw sugars in order to simply retain that portion of our own sugar market, we possess at present, how much more important when we wish to regain a portion of our own markets we have lost. For the sugar imported is of the better grades. We pay for it a little over Rs. 10 per hundredweight and for that we have exported we get considerably less than Rs. 6 per hundredweight.

A general opinion is that the raiyats of India are too poor to make any improvements in their methods. Still they can afford to los

considerably over 4 annas on every 16 annas worth of jaggery they produce (which they might save without any extra outlay), and the people as a whole, can afford to pay over 292 lacs of rupees to foreign countries for sugar which might be grown at home.

Geological Work.—Twenty-four miscellaneous samples were analysed for the Geological Department. These were ores, minerals and rocks collected by the Department, ores sent to them for analysis, and bar gold suspected to be stolen from the Kolar mines. But, so far as these analyses are of general interest, they will be reported on by the Geological Department. For none of them are of sufficient interest from an agricultural stand-point to report on them here.

Entomological Work.

At the beginning of the year, various insect pests were particularly destructive. Unfortunately, no supply of Paris Green was on hand or could be got in India. At the request of the Agricultural Chemist, Messrs. Forster & Co., of Bangalore, keep it in stock now. The Entomological Bulletin in press at present, gives full information regarding this and other remedies. Its application was demonstrated on some grapes growing in Bangalore affected with swarms of grasshoppers, and proved eminently successful, as no grasshoppers were seen on the plant for a month afterwards. The Green bug (*Lecanium viride*) as identified by Mr. Lionel de Niceville, Entomologist to the Government of India, has been particularly abundant on Coffee estates on the Bababuden Hills. The borer has also caused the planters more than usual loss. The boll worm was bad in the early part of the year in the Hoskote Taluk, especially, attacking the sesamum plants. Bordeaux mixture applied to check a blight affecting this crop apparently reduced their numbers. The insects classed together as *Kumbly Hula* have been exceptionally bad in the Kolar and Bangalore Districts. But their presence was reported too late to give any relief, as they had disappeared before the Department had been informed of their presence. Economic Entomology ought to receive much more attention than it has, and more work will doubtlessly be done in this branch of agricultural science as the Department increases.

Mycology.

In addition to leaf disease and black rot on Coffee and the black rot of Arecanuts, several diseases of minor importance have occurred on various crops. Attention was directed by the Deputy Conservator of

Forests of Coorg, to a disease, which he named " spike," attacki sandalwood in Coorg, and extending into Mysore territory. But no tra of a fungoid growth could be detected in the leaves, the only part of t tree examined. The Amildar of Hoskote reported the sesamum plan in his taluk to be diseased. They were attacked by the boll worm, a a fungoid disease not yet identified. Bordeaux mixture was prepared follows :—2 ounces of sulphate of copper dissolved in an earthen chat with hot water and diluted, slaked lime added until a drop or two o solution of Potassium Ferro Cyanide did not cause a brown colour appear. This mixture was poured into a four gallon pail and the latt filled with water. After the mixture was thoroughly stirred, it w applied with an old broom to the crop. A better plan, where larg areas are to be treated, is to dissolve, say 6 lbs. of sulphate of copper a wooden tub with hot water, slake about 4 lbs. of fresh lime with abo a gallon of water, strain this slaked lime and add it little by little to t copper sulphate until, after stirring the latter thoroughly, no bro colour is produced by a drop of a solution of Potassium Ferro Cyani The whole is made up to 20 gallons. When used, this mixture is dilut with nine times its volume of water and applied with a spray pu having a cyclone nozzle. The mixture was prepared and applied bef large gatherings in several villages in the Hoskote Taluk. The pla were entirely free from disease when visited two weeks later. Gra vines suffering from mildew and Roses affected with blight were a sprayed with this mixture. Both were thoroughly cured by one appli tion of the mixture. The roses were free from the blight 24 ho after the mixture had been applied.

The classification of correspondence is similar to that reported l year, only larger. And the various tours have been principally for t purpose of—

(*a*) Helping Coffee Planters with the selection and the start of experimental plots,

(*b*) Studying sugar-cane, and

(*c*) In connection with plant diseases and insect attacks.

An experimental plot for studying the growth of various gras and fodder plants is being started close to the Chemical Laboratory.

A. LEHMANN, PH.D.,
Agricultural Chem

TABLE

Showing loss of refinable sugar in the

No.	Description of sample.	Location.	Glucose per cent.	Sucrose per cent.	Total solids (Brix) per cent.
121	Juice from ordinary striped cane.	Kunigal..	·26	21·2	21·5
124	Jaggery from No. 121 ...	Do ...	7·1	80·2	...
125	Juice from ordinary striped cane.	Do ...	·23	21·6	22·0
128	Jaggery from No. 125 ...	Do ...	8·3	80·3	...
129	Juice from ordinary striped cane.	Do ...	·48	17·7	18·2
133	Jaggery from No. 129 ...	Do ...	7·7	80·4	...
141	Juice from Cheni cane ...	Kikkeri .	·43	17·0	18·6
142	Jaggery from No. 141 ...	Do ...	6·08	78·7	...
146	Juice from Cheni cane ...	Do ...	·17	18·9	19·8
145	Jaggery from No. 146 ...	Do ...	6·50	80·4	...
148	Juice from Cheni cane ...	Do ...	·41	16·65	18·4
147	Jaggery from No. 148 ...	Do ...	6·66	79·5	...
151	Juice from Cheni cane ...	Do ...	·43	16·65	18·0
150	Jaggery from No. 151 ...	Do ...	11·10	73·1	...
154	Juice from striped cane ...	Palhalli.	·84	17·45	18·3
155	Jaggery from No. 154 ...	Do ...	9·60	77·6	...
	Average ...	...	..	...	...

present system of jaggery boiling.

Per 100 lbs. of jaggery.				Remarks.
Juice required lbs.	Glucose originally in juice lbs.	Inverted lbs. about.	Loss in refinable sugar lbs. about.	
...	...	...	...	
378	·98	6·12	18·36	Probably limed to neutralize about ⅓ o the acids present.
...	...	...	...	
371	·85	7·45	22·25	Do do do
...	...	...	...	
454	2·18	5·52	16·56	Do do do
...	...	...	...	
463	1·99	4·09	12·18	The acid in half the required juice ne tralized with lime as tested by litmu paper.
...	...	...	...	
425	·72	5·78	17·34	Acid in juice nearly neutralized wi lime. Juice fermented.
...	...	...	...	
477	1·96	4·70	14·1	Do do do
...	...	...	...	
439	1·86	9·24	27·7	The acids in about half the quantity juice neutralized with lime. Ju fermented.
...	...	...	...	
445	3·73	5·87	17·6	
...	...	...	18·26	

TABLE

Showing loss by fermentation in refinable sugar

No.	Description of sample.	Location.	Glucose per cent.	Sucrose per cent.	Total solids (Brix) per cent.
144	Juice from Cheni cane milled in hot part of the day, sample taken from pan shortly before boiling began.	Kikkeri.	2·2	16·2	19·7
146	Juice from Cheni cane cut from the same plot as No. 144, milled early next morning, taken from chatty at mill.	Do ...	·17	18·9	19·8
150	Jaggery boiled from juice from Cheni cane milled during hot part of day.	Do ...	11·1	73·1	...
152	Jaggery boiled from juice from cane from the same plot as No. 150 milled late at night of the same day.	Do ...	5·5	83·1	...
153 (*a*)	Juice from striped cane, milled with a clean receptacle at 5 P.M.	Palhalli.	·31	...	...
153 (*b*)	Sample No. 153 (*a*) after standing an hour.	Do ...	·31	...	...
153 (*c*)	Sample No. 153 (*a*) after standing overnight (13 hours).	Do ...	·96	...	...
154	Juice from striped cane from the same field as No. 153 sample, taken from pan shortly before boiling began.	Do ...	·84	17·45	18·3

in the present system of jaggery boiling.

Per 100 lbs. of jaggery			Remarks.
Pounds of juice required.	Glucose formed by fermentation lbs.	Loss in refinable sugar by fermentation lbs.	
425	8·63	25·9	Fermentation took place in this sample after it was taken ; so that the figures are not correct but simply indicate the truth.
...	...	..	
...	5·6	16·8	In addition to 10 lbs. lost by other causes.
499	...	...	
...	...	...	
...	...	...	
...	...	...	
445	2·36	7·08	In addition to 17·6 lbs. lost by other causes.

TABLE

Showing loss in refinable sugar

No.	Description of sample.	Location.	Glucose per cent.	Sucrose per cent.	Total solids (Brix) per cent.
134	Juice, striped cane ...	Kunigal.	1·3	15·1	16·9
135	Jaggery boiled from No. 134	Do ...	8·0	78·3	...
158	Juice, striped cane ...	Palhalli.	·43	18·0	18·9
159	Jaggery from No. 158 ...	Do ...	3·0	85·1	...
133	Jaggery made from striped cane adjoining No. 135.	Do ...	7·7	80·4	...

when juice is limed to neutrality.

Per 100 lbs. of jaggery.				Remarks.
Juice required lbs.	Glucose originally in juice.	Glucose formed from sugar.	Loss in refinable sugar.	
...	...	...	..	
519	6·7	1·3	3·9	Each chatty as it came from the mill was limed until red litmus changed slightly in color.
...	...	...	...	
473	2·0	1·0	3·0	Each chatty limed to decided alkalinity as tested by litmus
454	2·18	5·52	16·56	For comparison with No. 13. Lime added to nearly neutrali... ½th lb. of volume of juice...

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Composition of varieties and

No.	Description of sample.	Location.	Glucose per cent.
107	Juice, ordinary striped cane ...	Oraghalli ...	·66
110	Ditto ...	Do ...	·57
121	Ditto ...	Kunigal ...	·26
125	Ditto ...	Do ...	·23
129	Ditto ...	Do ...	·48
	Average ..	... ..	·44
105	Juice, elephant cane ...	Oraghalli ...	·86
108	Ditto ...	Do ...	·67
112	Ditto ...	Do ...	·90
114	Ditto ...	Do ...	1·09
123	Ditto ...	Kunigal ...	·31
126	Ditto ...	Do ...	·45
131	Ditto ...	Do ...	·38
	Average ...	... ...	·67
111	Juice, hard thin cane, Cheni ...	Oraghal l ...	·77
141	Ditto ..	Kikkeri ..	·43
146	Ditto ...	Do ...	·17
	Average ...	... ...	·46
122	Juice, bellied striped cane ...	Kunigal ...	·77
126	Ditto ...	Do ..	·45
130	Ditto ...	Do ...	·38
	Average ...	.....	·60
103	Juice, striped cane, 18 months old	Saklespur ...	2·1
102	Juice, No. 103, twelve months old	Do ...	7·7
104	Juice, white cane, 18 months old...	Do ...	·9

influence of immature cutting.

Sucrose per cent.	Total solids (Brix) per cent.	Quantity of juice containing 100 lbs. refinable sugar. (Disregarding ash.)	Remarks.
18·3	19·5	589	
20·2	21·7	525	
21·2	21·5	484	
21·6	22·0	473	
17·7	18·2	597	
19·8	20·6	534	
17·8	18·7	622	
18·1	19·4	596	
17·5	18·9	636	
17·8	19·5	640	
21·6	22·1	477	
19·8	20·8	529	
19·8	20·7	525	
18·9	20·0	575	
16·6	17·8	664	
17·0	18·6	619	
18·9	19·8	539	
17·5	18·7	607	
20	21·5	542	
19·8	20·8	529	
18·2	18·9	587	
19·3	20·4	553	
18·3	20·6	709	
14·8	22·6	Unlimited,	
17·8	18·7	625	

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LABORATORY & OFFICE OF THE MYSORE DEPARTMENT OF AGRICULTURE.

DEPARTMENT OF AGRICULTURE
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THIRD ANNUAL REPORT

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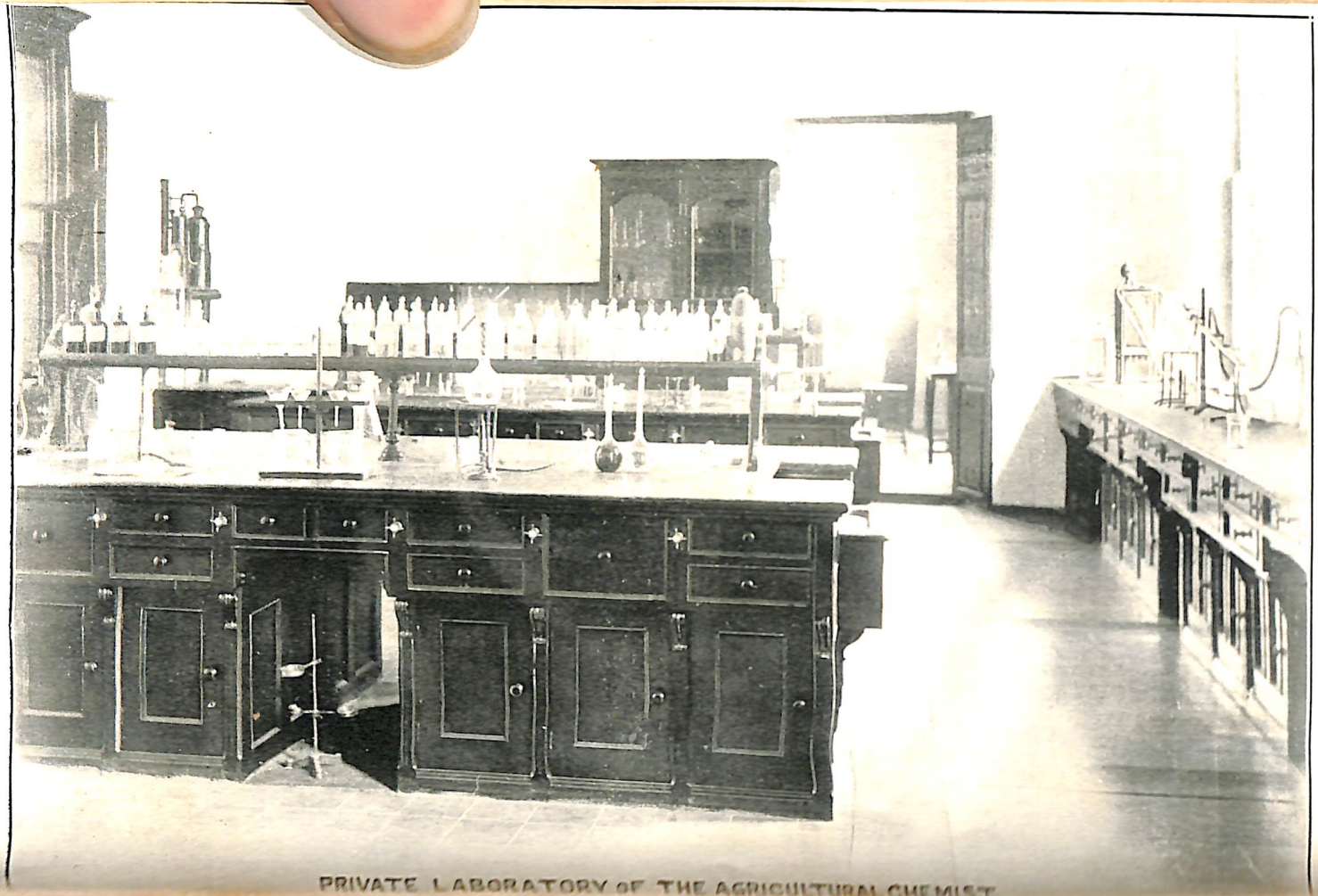
Do	...	B. Venkata Rao, B.A.
Probationary Asst. Chemist	...	A. K. Yegna Narayana Iyer, M.A.



PRIVATE LABORATORY OF THE AGRICULTURAL CHEMIST

ANNUAL REPORT OF THE DEPARTMENT OF AGRICULTURE, GOVERNMENT OF MYSORE, FOR THE YEAR 1901-02.

Staff.

The only change in the staff has been the addition of an Associate of the College of Agriculture at Saidapet, to assist in Plot Experiments and general office work. I must thank all in my Department for their willing and cheerful assistance, and wish to again mention the names of Mr. B. Venkata Rao, Assistant Chemist, and K. V. Krishnasami Iyer, chief clerk, as particularly praiseworthy in this direction.

The Work of the Department.

The work of the Department during the year may be divided into the following five heads :—

(*a*) Analytical work.

(*b*) Tours.

(*c*) The distribution of information on agricultural matters.

(*d*) Agricultural Experiments.

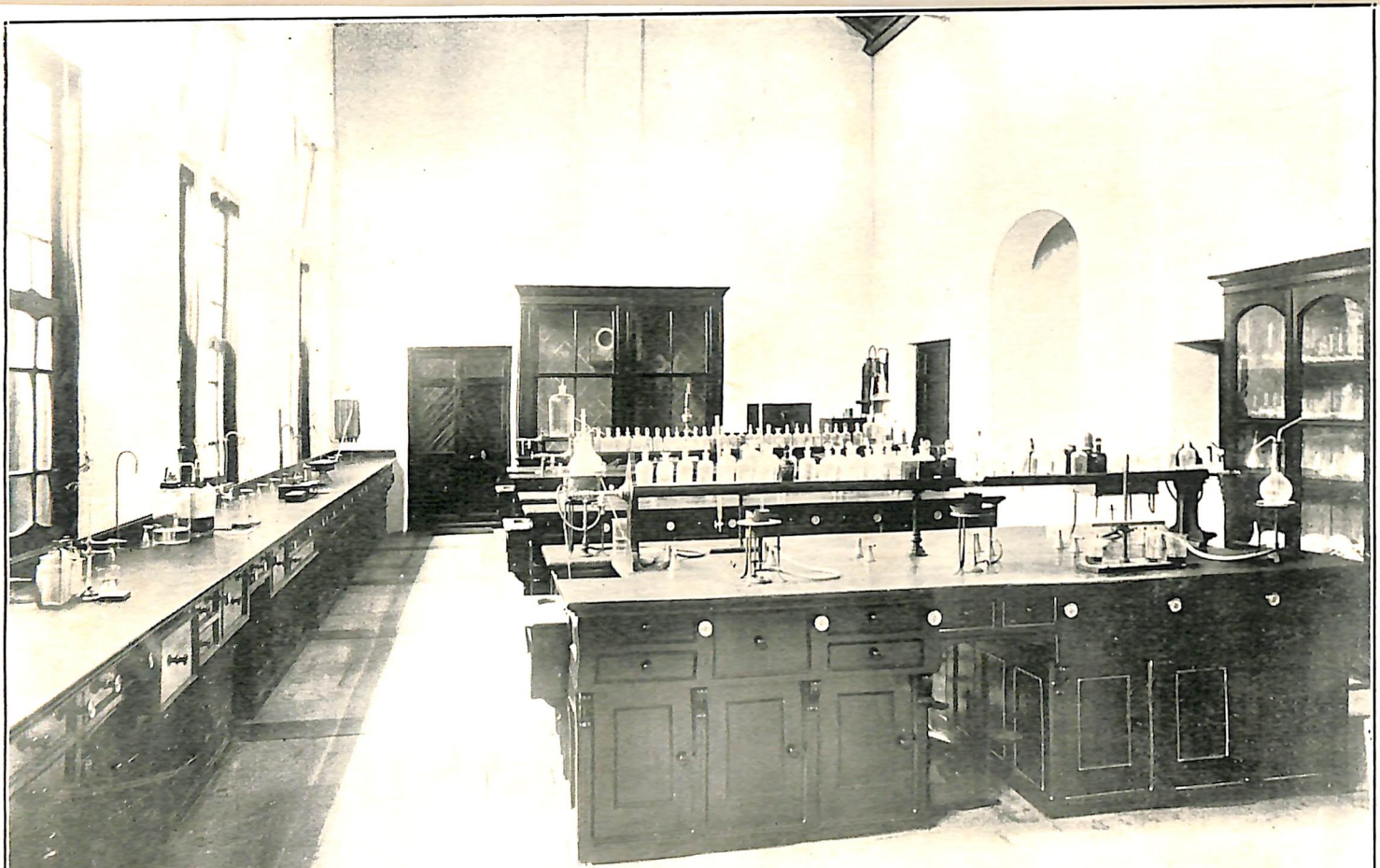
(*e*) The fitting of the remainder of the Laboratory.

Under the last of these headings very little need be said in this report notwithstanding that it absorbed a large portion of the time of the Agricultural Chemist. The nature of the work required for fitting a chemical laboratory is such that no one could be found in Bangalore to do it satisfactorily even after detailed plans had been prepared. The work which had been given out on contract last year was so badly done that a large portion of the fittings had to be taken out again by the Agricultural Chemist and his subordinate staff. After being trained in the work the Assistant Assayer did very well indeed, but of course required constant supervision. The principal part of the carpenter work was however done by contract and was done very satisfactorily indeed, especially after the contractor understood exactly what was required. Detailed plans had however to be made for everything by the Agricultural Chemist. Now that the laboratory is practically

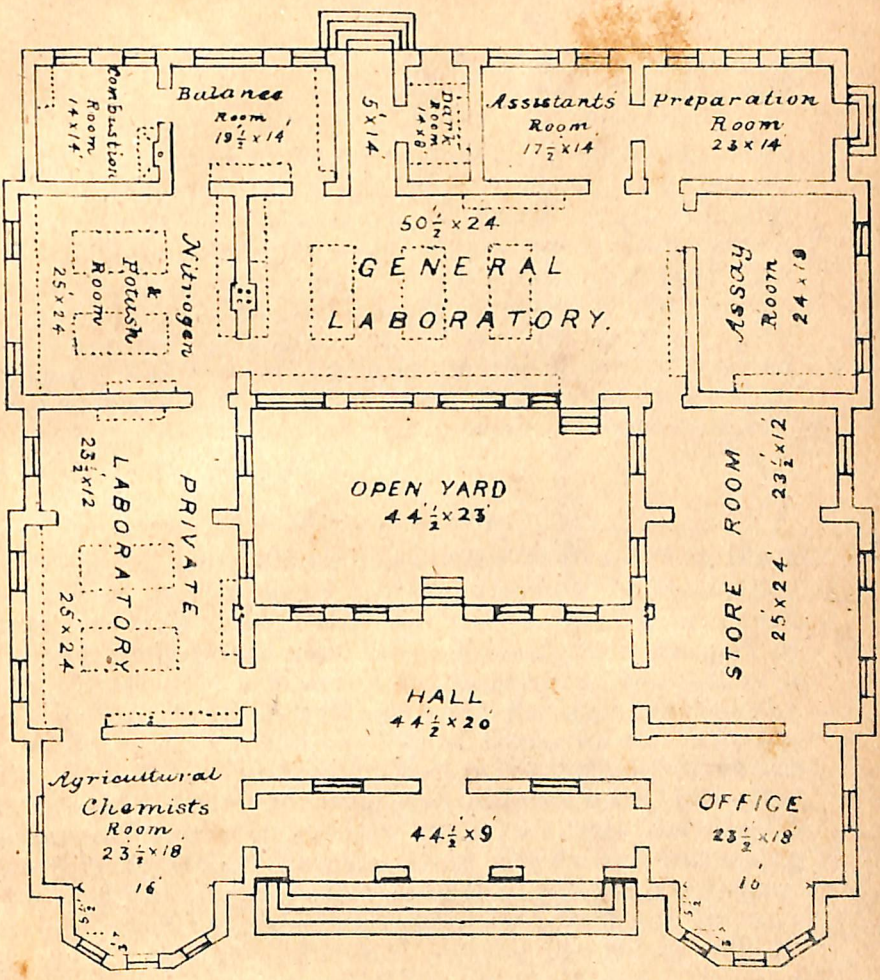
completed, a short description of it may not be out of place, especially as it is practically the first Laboratory of its kind in India and can compare favorably with the average Agricultural Chemical Laboratories in other countries.

Laboratory.

The distribution of space and the size of the various rooms may be judged from the accompanying ground-floor plan. The general Laboratory receives its light almost exclusively from the open court-yard in the centre of the building. It was feared at one time that this would make it a little dark. But it has all the light any one could desire. It is decidedly the coolest room in the building, probably on account of having other rooms to protect it on the east, south and west. The roof is tiled and lined with wood on the inside. The latter forms the ceiling of the various rooms, thus helping to make them even higher than the already high walls (19 feet) would make them. In the main Laboratory are three central working benches 11 feet long and 5 feet wide with earthenware sinks at each end. On the centre of each bench is a shelf for reagents and underneath this are 12 gas taps, all so arranged that the gas supply can be regulated from the front of the benches so as to avoid disturbing any apparatus which may be standing on the benches and blocking the way to the taps when regulating the gas supply to the burners. Over the sinks at each end of the bench is a triple water tap. The distance between the benches is 5 feet. Running along nearly the full length on one side of this Laboratory is a side working bench two and a-half feet wide with goose neck water taps every 7 feet and a gas tap about every 22 inches. All the benches are 3 feet high. The top foot is provided with drawers of various sizes and the two feet at the bottom are, as is usual, closed in by doors and used as cupboards. At one end of the Laboratory is a wash up sink provided with hot and cold water, and drain boards, and bench space for the dirty glassware ; at the other end are the fume cupboards with large water bath and sand bath, a short bench and the still to supply the necessary distilled water. On the remaining side largely cut up by doors are cupboards for holding the apparatus in general use, chemicals and standard solutions and samples prepared for analysis. All the wood work is of teak finished in its natural colour and trimmed with blackwood mouldings. The tops of all the working benches are impregnated with paraffin to make these more resistant to alkalies and acids. The pipes, although laid in drains



MAIN LABORATORY OF THE MYSORE DEPARTMENT OF AGRICULTURE.



GROUND PLAN
OF
THE LABORATORY & OFFICE OF
THE DEPARTMENT OF AGRICULTURE.

Scale 25' = 1"

under the floor and concealed in the working benches, can be got at readily at any time. They were nearly all laid down by the Agricultural Chemist and his subordinates, as no competent man could be found to undertake the work. The fittings are nickel-plated brass. The nitrogen and potash rooms and the private laboratory are, barring a few changes, reproductions on a smaller scale of the main Laboratory. The apparatus and store-room has been built so that it can be easily converted into a laboratory if required. The principal windows are counterpoised sliding sashes fitted with plate glass. And the greater part of the floors is covered with a very hard, though not glazed, earthenware tile. The building is constructed of gray granite and is both comfortable and neat in appearance.

Analytical Work.

During the year 105 samples were analysed. Of these fully one-half, *viz.*, 54, were received through the Geological Department. These kept the two assistants fully occupied. The samples comprised gold ores, minerals and samples of bar and sponge gold. Many of the analyses of the gold ores were done for private individuals and a fee was charged and collected for them by the Geological Department. The analyses of bar gold and sponge gold were virtually done for the Police Department and only sent in through the Geological Department. These requests for analyses of samples of gold supposed to be stolen from the Gold Fields are increasing and the amount of work entailed in the analyses is considerable. However, as a chemical analyses is practically the only means by which the Kolar gold can be identified, and as, thanks to the energetic work of the State Geologist, some of the Kolar gold can now be identified with absolute certainty by these analyses, this line of work deserves every encouragement in a State where the gold mining industry is such an important factor. The analytical results of the samples sent through the Geological Department will be published in the memoirs of that Department.

The remainder of the work (51 samples) were done for this Department, and are principally the work of the probationary assistant and myself. The samples are made up principally of sugars, fertilizers and soils and are published in part in the appendix to this report.

Tours.

In all ten tours were made during the year and varied in extent from a few days to a little over a month. Those of

only a day's duration are not of course considered as tours. They were for very varied purposes, the examination of lands of various kinds and for various purposes, the study of the sugar industry, to examine crops attacked by insects, to see the experimental plots of planters, and to see coffee in other parts of India, *viz.*, Coorg and the Shevaroys. The information gained on the Coorg tour has already been partially published in Bulletin No. II of this Department. The tour to the Shevaroys was for the purpose of seeing the effect of cutting out every alternate tree on the estate of Mr. Leeming, the energetic planter who first practised and advocated this system.

Leeming's System.

Every agriculturist seeing coffee as generally grown in Southern India for the first time, must be struck by the fact of its being crowded very much. Whether such crowding is necessary or not, or whether coffee will thrive and crop equally well per acre when not crowded so much and whether the soil can be kept in as good or better tilth when the coffee is not so crowded, are all questions which can be debated almost indefinitely. They have all their pros and cons, and in how far the one overbalances the other can only be proved by experiment. For absurd as it may seem to a casual inexperienced observer, the crowding system has something in its favor.

Distance between Coffee.—No doubt coffee trees ought, like other plants, to grow a proper distance apart. And no doubt as with other plants there is some latitude in this distance for the same soil and the same climate. For example in sugarcane practically the same yield of sugar was one year obtained per acre at the New Orleans Experiment Station when the rows were three feet apart and when double that distance, and the intervening distances give almost the same result. In this case we may say that 4½ feet apart was the proper distance, but by giving one and a-half feet either way we still got practically the same yield per acre. Similarly if we know the proper distance to plant coffee, we should likely find that planting it a little closer or a little wider apart would make little difference in the yield per acre. But what is the right distance on one estate may not be the right distance for another estate. There is no doubt that on one field I have seen on which the coffee was, I think, planted 6 feet by 6 feet, it was not overcrowded, while on another field in the same district planted practically the same distance apart there was no doubt of the coffee being overcrowded. In cases where coffee is

crowded an attempt is sometimes made to atone for this by heavy pruning. Within certain limits this is no doubt effective. But undoubtedly it is expensive both on account of the extra labour involved and on account of the energy and plant-food wasted by the trees. Some times the overcrowding is however so great that even heavy pruning will not keep down the wood to the limits the space will permit. Instead of producing crop the trees run to wood. A deep digging may possibly check some of the tendency to produce wood by cutting off a lot of the roots and reducing the vigour of the tree. But there are fields on which even this check was not able to keep the trees within the desired limits. They still produced wood instead of crop. So far as my present experience goes it leads me to believe that the knife should be very sparingly used, and if trees require heavy pruning they are growing too close together. How far the branches of neighbouring trees should be permitted to touch each other it is difficult to say at present. This involves not only the subject of what is best for the tree itself as such but also the welfare of the soil; and the condition of the latter of course reacts on the former. For the trees themselves it is probably of advantage to have them so far from each other that none of the branches of neighbouring trees touch each other. For the mechanical condition of the soil, it is however more than likely that the closer the trees the better. The soil will have more shade, more mulch and be less likely to become infested with grass. The benefit of these latter factors is not fully recognized as yet. Still it will be difficult to overestimate them. Of course the fewer the number of trees the larger the crop from each individual tree must be to make up the same yield per acre. Just how far the trees should be apart on a given piece of land to give the most favorable returns when considering all the factors, experiments alone can show. They have shown us that in certain places the coffee is undoubtedly too crowded. But to judge from this that the coffee is overcrowded in all places would be a fatal mistake. For they have not even proved to us that it is overcrowded as a rule. And as it is easier to cut down a tree than to grow one, it would not be wise to experiment on too large a scale.

Borer.—Fears have been expressed by many that if the trees were further apart than they are as a general rule now, the borer would be likely to create more havoc among them. This may be the case shortly after the trees have been thinned out. But when they have grown that way for a year or two (provided, of course, that the need of thinning

out was indicated by their vigorous growth) the trees protect their own stems to such an extent by the drooping branches which touch the ground that little fear need be entertained on this score, provided the life-history of the borer as generally accepted at present is correct. The stem will be even more perfectly shaded by its own branches than it was before, notwithstanding that its neighbour is removed.

Manures, Cultivation, Suckers, Branches.—These and other subjects are often discussed in conjunction with that of growing coffee further apart. They require to be experimented with much more than has been done at present before anything which deserves to carry weight can be said about them in this connection. I cannot see how the distance between the trees can have any influence upon the quantity of manure which ought to be applied, provided the same crop of coffee per acre is expected. Cultivation is made easier on the one hand by the trees being further apart but on the other hand the branches being so much lower makes it more difficult. Furthermore as has been proved in Coorg, the stirring of the soil is, to say the least, not necessary as a rule if the coffee is close enough to cover the ground. Trenches are supposed to have given marvellous results. Why they should do so it is difficult to say, except that the earth thrown out may possibly act as a mulch. If that be the case, the natural mulch of leaves, if it exists, is doubtless much better than the mulch of earth thrown out of the trenches. By making the latter the planter will lose his mulch of leaves for the time being to a large extent and produce an uneven surface and thereby prevent a uniform distribution of his mulch of leaves (a very important matter) for some time to come. Where surface wash exists and the trenches are used to catch this, their beneficial influence can of course be easily explained. If under the existing circumstances on any particular estate they are really showing beneficial results, of course well and good, and I sincerely hope that we may find out the cause for this beneficial result so as to be able to apply the trenches intelligently. For it is not likely that trenching can be practiced under all circumstances with success.

Fertilizers.

The agriculturist in Mysore realizes, no doubt, that manures are of great value to him. He prizes the cattle manure very much and collects various natural fertilizers such as the leaves and flowers of the Hongay tree for manurial purposes. He carries into his cultivated fields (principally his

arecanut plantations) jungle soil or any other kind of soil he can secure free of cost both for the manurial value he believes it to contain and for covering up the roots of the palms which may have been laid bare by the washing away of the original soil. The better educated and more prosperous agriculturists make use of various oil cakes and to a more limited extent of bone meal. But with the exception of the planters the other commercial fertilizers are practically unknown, or at least unused.

Plants require foods just as animals do, only the food is of a different kind. The soil is among other things a store-house for plant-food, and in common with other store-houses will become exhausted in time if we do not return to it the plant-food removed from it. The substances replacing this plant-food are called manures. Few of these manures supply everything the plant requires to make it grow. But most soils contain some of the plant-food which is required in small quantities by the plant, in such relatively large quantities that the supply they contain is practically inexhaustible, as for example, iron, and we do not require to consider this kind of plant-food at all when speaking of manures. Generally there are three or four kinds of plant-food of which the soil is liable to contain a comparatively small quantity and which as a result we must be ready to supply in the form of manure when needed. These substances which are called, Nitrogen, Phosphoric acid, Potash and Lime can be separated out of the soils and out of the manures by Chemists, who can therefore tell us to a certain extent what the soils are deficient in and what fertilizers must be applied to give the best results. For the soils are not all alike and the plant-food one soil may be particulary deficient in, another soil may have in sufficient quantity for immediate use. Also the manures have not got these substances in equal quantities. One kind of manure contains a particularly large supply of one kind of plant-food, another has principally another kind of plant-food which it can supply to the soil. One manure may give large crops on one field to which it supplies just the kind of plant-food which is missing while it will fail to produce an equally good crop on another field however much of it may be applied, if it does not contain that kind of plant-food which is required for that particular field. For this and other reasons these one-sided or special fertilizers are not used much in countries in which agricultural chemists have not been at work. As a rule only such manures find favor there which supply all the plant-foods which are likely to be wanting on an average soil. We may therefore call

these manures complete fertilizers to distinguish them fr
the one-sided or special fertilizers which supply princip
one or, at most, two kinds of plant-food. These comp
fertilizers are generally excreta from domestic animals.
such, the different kinds of plant-food are generally pres
only in small quantities, and not always in the proport
in which they are required by the crop on a certain s
As a result, these manures may often be mixed with sm
quantities of special fertilizers to great advantage. For, t
small quantity of special fertilizer is supplying what happ
to be deficient in the general fertilizer, and it having
comparatively large percentage of this one constituent,
equivalent to a large quantity of the general fertilizer w
which it is mixed. For example, if a soil happens to
greatly deficient in phosphoric acid, one pound of bone m
which contains 20 per cent of phosphoric acid may be
times as valuable as a cattle manure containing 0·4 per c
of phosphoric acid. Or if the soil happens to be particula
deficient in potash, one pound of ashes containing 5 per c
of potash may be equal to 25 lbs. of manure containing
addition to 0·2 per cent of potash, 0·4 per cent of phospho
acid and 0·5 per cent of nitrogen. For the latter not be
required would be practically valueless. If, however, the s
were equally deficient in both these constituents and nitro
as well, no amount of ashes or bone meal would do mu
good by themselves. It would require ashes *and* bone m
and poonac as well. In that case about one pound of bo
meal, two pounds of ashes and four pounds of poonac, wo
contain the plant-food found in 50 lbs. of cattle manu
having the composition given above. Therefore even if
the constituents of plant-food supplied by cattle manure a
deficient in the soil, we may still, to a large extent, repl
or augment cattle manure if we desire to do so. There a
of course other special manures which may replace th
mentioned above. Saltpetre may take the place of the as
and to a certain extent that of poonac as well. Fish manu
may replace poonacs, also bone meal, though it does n
possess as high a percentage of phosphoric acid as the latt
Blood manure may also be used instead of poonac and is m
concentrated than it. Besides these, there are a lot of impor
fertilizers which may be used. So that the agricultur
has, in addition to the manure he produces in his own stab
a large number of commercial fertilizers to draw from, sho
he desire to augment his supply of manure ; and mo
judiciously spent in buying fertilizers is generally well spe
However, when buying any fertilizers the purchaser ough

know exactly what he is buying. Fertilizers even of the same kind vary very much, as will be seen by comparing the analysis of some of these fertilizers as found in the appendix. In each case, therefore, purchasers should try to get a guaranteed analysis indicating the quality of the fertilizer they intend to buy before investing their money.

The raiyat is not likely to spend any large amount of hard earned money in manures. He has less of it than many of his brother agriculturists in other parts of the world, and though he prizes cattle manure very highly and collects some other manures such as Hongay leaves and flowers (for which he does not require to pay) he does not value manures as highly as many of his brethren in other countries, and much as cattle manure is valued, the care bestowed upon it is very imperfect.

CATTLE MANURE.—In Mysore two systems of collecting this manure exist. In the one the stables are cleaned out daily and the manure placed in a heap or a pit; in the other, the manure is allowed to accumulate in the stables. But in neither case is bedding or litter used to any considerable extent and as a matter of course the urine must be lost very largely, if it does not drain away entirely. Of course, the relative amount and relative composition of the dung (the solid excreta) and of the urine (the liquid excreta) vary very much with different feeding. But on an average, with well-fed cattle, the quantity of plant-food excreted in the urine is about the same as that excreted in the dung as determined by Messrs. Muntz and Guard in their experiments in Normandy. About half the quantity of the plant-food of the manure is therefore lost if the urine is not preserved. In fact, probably a little more than half. But so far as the quality of plant-food is concerned, the loss is several times as great. Probably, if applied directly to the field in suitable dilution, the urine produced by a herd of mature cattle would be, say, four times as valuable as the dung, for in the urine the nitrogen is directly available for the plants, while in the dung it is comparatively inert. Perhaps one practical illustration from actual agricultural practice may serve to bring home this point with greater force. A farm well known to me, on which practically all the urine was allowed to go to waste formerly, has increased its average yearly crop returns for the past ten years by 300 per cent since carefully preserving all the urine in its stables, and that of course without increasing the expense of cultivation. In order to save this urine it is necessary to resort to one of two principles, either to have water-tight floors for

the stables and collect the urine in cisterns or water-tight pits, or to use enough bedding or litter to completely absorb the urine. The former principle though used in parts of Europe will, I fear, not answer well in this climate. For the latter purpose very varied substances may be used as absorbents; straw, dry earth, dry leaves, or dry ferns will answer. Straw is the material most extensively used for this purpose in Europe and America. But until fodder for stock becomes much more abundant than at present, the straw grown in Mysore will be required almost exclusively for feeding purposes. Many of the hill tops in the Malnad are, however, clothed with a dense mass of rank grass; and instead of burning this, as is so frequently done at present, it might easily be collected by enterprising raiyats and used for litter. In places where these hills are steep it might be tied into bundles and rolled down the hills, as is frequently done in mountainous countries. Jungle soil if well dried, also forms a good absorbent. But of course, if wet, is practically valueless. In order to keep it dry it must of course be put under shelter on a platform some distance say, six inches or a foot from the ground. Green leaves and twigs as employed at present to some extent in the Malnad are of course practically useless as an absorbent, though they doubtlessly help to add a little to the comfort of the cattle when housed in stables not cleaned out daily. Dry leaves serve, however, a very useful purpose as an absorbent, and furthermore like straw add some manurial constituents. In the appendix are given the analyses of several varieties of leaves gathered in Hassan District from the ground after dropping from the trees. These leaves must of course be kept dry just like all other bedding materials, if they are to serve the purpose of absorbents for the liquid manure.

With a better quality of manure, better care must also be taken of it. A manure containing little soluble plant-food can lose little by being leached with rain water, while that containing a very large proportion of soluble substance can of course lose much more. But in the better quality of manure containing considerable bedding or litter of an organic nature, especially if it is straw, there is much more danger in Mysore from a loss by excessive fermentation than from leaching. Apparently, the most rational system for preserving the urine is to apply absorbents in the form of dry litter in sufficient quantity to completely absorb the urine and keep the cattle comfortable and not clean out the stables until the manure can be applied directly to the field where needed, and spread there. For, to leave the manure in

loose heaps would cause a considerable loss of plant-food by excessive fermentation.

Fermentation is due to the presence of little plants called Bacteria living in the fermenting substance. Those which cause loss in manure by "over heating" require air to enable them grow vigorously. By keeping out this air from the manure we reduce the fermentation and the way to keep out the air is to either keep the manure wet so that the little spaces in the manure heap are filled with water instead of with air, or to keep the manure packed so tightly that very little air can penetrate it. By keeping the manure in the stables trampled tight by the stock, the air-spaces in it become very much reduced and the urine fills up a large portion of the remaining spaces, so that fermentation is reduced to a minimum. If, however, the stables are cleaned out every day and enough litter is used to absorb the urine, the manure will be in loose heaps, air will easily enter, fermentation will go on rapidly and a considerable loss of nitrogen will occur. The looser these heaps, the more they are protected from rain, and the hotter the weather the greater this loss will be. There are, as will be observed, at least, two sources of loss in manure, the one from excessive fermentation, the other from leaching. By protecting loose manure heaps from rain we reduce the loss from leaching, but probably greatly increase the loss from excessive fermentation. By keeping such heaps uncovered and permitting rain to soak into them we probably lose less. For although there will doubtlessly be some loss by leaching, the loss by excessive fermentation will probably be reduced to an equal amount though very heavy showers would probably cause more harm than good. These questions require careful investigation in this climate if the manure is to be kept in loose heaps. But by keeping the manure well packed in the stables both these sources of loss are very materially reduced if not totally avoided. As has already been stated the cattle continually trampling on the manure compress it very much and reduce the air-spaces in the manure to a minimum. The system gives entire satisfaction in Germany and in those places in Canada in which it has been thoroughly tried. And as in Canada, during the summer months, the heat is occasionally for a few hours nearly equal to that of our average hot weather in Mysore, there is every reason to believe that the system will work well here if proper "bedding materials" are employed. And the intention of the Department is to make experiments with various absorbents which might be used for litter as soon as an opportunity offers itself to do so.

In the appendix are given the analyses of two samples of village cattle manure from Hassan District. The one No. 34 is comparatively fresh, the other No. 35 has been kept for some years in an exposed heap; neither of them contained any litter and in both but little of the urine has been preserved. Neither of them has probably suffered very much from over fermentation; as since they contained no litter, little air can have penetrated the comparatively compact mass. Furthermore, the very large percentage of sand both these manures contain, will have had a tendency to retard rapid fermentation. The samples as received contained 61·23 per cent and 72·59 per cent of sand and gravel of which 27·5 per cent and 33·9 per cent of gravel respectively were sifted out of the manure before analysis. It would be interesting to know how much of this sand had passed really through the animal and how much has been admixed afterwards by digging out a portion of the floor of the stables when cleaning them out each day. There must however have been some considerable loss of weight in the older manure but taking for granted that the manures were of about uniform quality to begin with, this loss of weight has in no way been compensated for by a better quality of the older manure. For, even after making due allowance for the larger percentage of sand in the older manure and taking account of the difference in moisture, the older manure is only $\frac{3}{4}$ of the value to the fresher product pound for pound. The maxim to apply the manure as fresh as possible to the fields where they are to be used, applies (so far as I can judge at present) with the same force in India as it does in America.

Poonac.—In the appendix are given the analyses of two poonacs, one, a white castor and the other hongay. Pound for pound this particular sample of white castor is twice as valuable as the sample of hongay, and barring the expense of application, it is at least ten times as valuable as the better of the two samples of cattle manure referred to above, and owing to the fact that the nitrogen in the cattle manure is not likely to be in as available a form as in the poonac, the latter is likely to be even more valuable than indicated above.

Bone Meal.—Two samples of bone meal were analysed. The results are found in the appendix. No. 11 is much below the average in both nitrogen and phosphoric acid, and though sold as bone meal in India, would not pass as such unchallenged in Europe or America. No. 12 is a good average untreated bone meal. Taking the latter to be worth, say, Rs. 51 per ton and not making allowance for the differ-

ence in mechanical condition sample No. 11 would be worth only about Rs. 37 per ton. Bone meal, though a very favourite fertilizer with planters, has not received the attention from raiyats which I believe it deserves. On the Experimental Farms in Northern India it has, I am told, not given good results. But so far as my experience goes, the plant-food which bone meal contains is deficient in Mysore soils, and bone meal is undoubtedly the cheapest form in which to apply this plant-food, and considering the large percentage of iron in the soil, it is possibly the best form in which to apply it; especially if the soil is not deficient in organic matter. In Germany, it is true, the phosphoric acid in bone meal gave very bad results even on soils which required a phosphoric acid fertilizer. But in Japan, where the conditions are more nearly like those in Mysore, the results were very satisfactory, and the indications are that in Mysore it will prove equally satisfactory, especially where the organic matter is not deficient. One of the reasons why bone meal has not been used to any large extent is doubtlessly that it is difficult to grind bones to powder, and that when applied whole they are of little value. Of course the easiest way to prepare bones for use as a fertilizer is to disintegrate them by the use of the machinery made for the purpose. But this is comparatively expensive except when large quantities of bones have to be treated. To use sulphuric acid for the disintegration of bones after they have been broken to pieces by hand with hammers is much too expensive in India, where the acid cannot be bought cheaply; and further more it would require more skill and practice in the operation than the average raiyat possesses. Other ways have, however, been recommended, and the one likely to give good results in Mysore is to mix equal quantities of bones (broken to pieces by the use of hammers) with ashes in alternate layers and pour sufficient water over the heap to moisten it thoroughly without letting any of the water run away, and to keep it in a moist condition for several weeks or perhaps two months. The best results are likely to be obtained if the heap is nearly as high as it is wide or long, so as to have as little surface as possible. Of course a layer of ashes ought to be at the bottom and top and on all sides of the heap. This method is reported to have given very good results and is well worth a trial. Another method is to put the broken bits of bone in the manure heap. This gives good results when the manure heap contains the greater part of the urine, considerable quantity of litter and some horse manure. Whether it would be likely to give satisfactory results in the manure heap of

the average Mysore raiyat is doubtful. Nevertheless it is worth trying too.

Fish Manure.—Though this manure is used, I believe, to a considerable extent by the raiyats on the sea coast, it is only the planters and almost exclusively the European planters, who use this manure in Mysore. In the appendix will be found four analyses of fish manure in which the nitrogen varies from 3·96 per cent to 8·72 per cent and the phosphoric acid from 1·72 per cent to 6·12 per cent. If the richest of these manures could be bought for Rs. 52 per ton, the poorest of these four samples would only be worth Rs. 22 per ton, or considerably less than half what the best of these four samples would be worth. What applies to fish manure and bone meal applies to a greater or less extent to all manures and indicates that the quality of a manure must be considered as well as the quantity. Whether we are using the fertilizer produced on the land (such as cattle manure) or are using such manures as bone, poonac or fish, we should recognise that these manures may vary very much in themselves and always strive to procure the very best value we can get.

To determine the relative value of manures a large number of things have to be taken into consideration such as the "solubility" of the manure and its mechanical condition. It must also be remembered that phosphoric acid cannot take the place of nitrogen or potash or *vice versa*. That each plant-food has its own work to perform, which cannot as a rule be done by any other kind of plant-food. Making allowance for all these things we may say that nitrogen is generally about three and a half times as expensive as either phosphoric acid or potash.

Together with the analytical results of the samples of fish will be found that of a sample of prawn manure, which resembles fish in many respects.

Sugars.—In the appendix will be found the composition of 15 samples of juice from sugar-cane, four samples of juice from sugar-beets and 12 samples of jaggory. Samples No. 167 to No. 195 inclusive were from Sulekere. The object of the work was primarily to see how the Sulekere sugar-cane compared with that of other parts of the Province, with a view to encourage if possible the establishment of a modern Sugar-house under that large tank where thousands of acres of land, all in one block, could be devoted to sugar-cane growing. Unfortunately, owing to lack of labour in the harvesting season, the crop of cane growing there was over ripe. Very few seed heads were present, however, and only

here and there had the cane begun to sprout at the joints. The cane was not at all vigorous and in places dead and stunted canes could be easily picked out. The latter was possibly due to the excess of alkali in the soil, which, I fear, was present to a greater or less extent in a larger portion of the lands under the tank. In some places the "alkali" or "choulu" was present to such an extent that absolutely nothing appeared to grow on them, and in many places the quantity present had apparently affected the growth of the cane to a considerable extent, as indicated by a poor growth and many stunted and dead stalks on these spots. Of course, lack of manure may have had something to do with this in certain fields. But undoubtedly the "alkali" was an important factor.

When comparing the percentage of sugar (sucrose) found in the cane grown in this locality with that grown in other parts of the State (*vide* the second Annual Report of this Department) it will be found to be very low. This is likely due (to a large extent at least) to the "alkali" or "choulu" in the soil. As will be noted the average of the 14 samples of Sulekere cane juice was only a trifle over 15½% of sucrose, and the highest percentage was only 16·3 of sugar, while last year out of the 33 samples of cane juice taken at various places throughout the Province, only three dropped down to this maximum of Sulekere cane juice, and one of these was a decidedly immature sample. The average of these 33 samples was fully 2½% higher than that at Sulekere (being a little over 18% and the maximum was nearly 5½% higher than at Sulekere, *viz.*, 21·6%. The glucose of the Sulekere cane is on the other hand quite double that found in cane grown in other parts of the State. The coefficient of purity is necessarily much lower, and above all the percentage of soluble ash in the jaggories is very high indeed. Unfortunately I have no figures as yet for soluble ash in jaggories of other parts of the State for comparison. The soluble ash retards the crystallisation of sugars even more than the presence of glucose, and for sugar production a juice containing a high percentage of soluble ash is avoided even more than one containing a high percentage of glucose. In fact No. 188 and No. 195 contained so much soluble ash that in conjunction with the very high percentage of glucose they contained, it prevented the sugar completely from crystallising. All attempts to make of them anything but a soft, gummy, somewhat elastic mass were fruitless. Under these circumstances Sulekere could not be recommended as a suitable site for a *pioneer* sugar factory. In the

sample No. 195 referred to above the glucose is frightfully high, and fully 10% of it has been formed during boiling, and this notwithstanding that sufficient lime had been added to the juice before the boiling began. Judging from the results obtained last year not more than half this amount can, I believe, be normally attributed to over-heating. To what other factor or factors the remainder of the inversion is due I am unable to say at present. Fortunately nothing of the kind was noticed in other parts of the State. Sample No. 188 which was taken from the same field as sample 195 showed the same peculiarity but not quite to the same extent. In it the soluble ash and the soluble carbonates were even higher than in No. 195, and there is some doubt as to its having been limed to neutrality. In all the samples a considerable amount of inversion has taken place during boiling, and in No. 189 to No. 195 inclusive this cannot be due to improper liming.

Having spoken about "alkali" or "choulu" lands under this heading, I may mention that, following my recommendation, a particularly bad piece of such land at Sulekere was thoroughly drained and has very materially improved since. None of the white incrustation has appeared on the surface this year, and as time goes on, the improvement is likely to continue. In the same digression I may also state that as a general rule sugar-cane is treated too much like paddy in the matter of irrigation, and that according to the experience in other countries sugar-cane resents such treatment. Our quality of sugar-cane is, as a rule, very good, but we have to learn a lot about both its cultivation and manufacture. What can be done is illustrated by a plantation on the Hawaiin Islands. One of its fields about 100 acres in extent produced on the average a little over *ten tons of sugar per acre.*

In the appendix are also given several analyses of sugar beets at various periods of their growth. They were planted by Mr. G. L. Chambers in his compound at Bangalore on August 15th of last year. The analysis made on March 21st of this year after the beets had been growing 7½ months is similar to that of beets in other countries. But notwithstanding this, the sugar beet can never be seriously thought of as a sugar-producing plant in Mysore, where sugar-cane offers such vastly superior advantages to the beet; at any rate no such thought need be entertained until the manufacturing processes of sugar-making in Mysore have been placed on a totally different basis than they occupy at present.

INSECT PESTS.

Entomology and Chemistry are so far removed from each other that one man cannot possibly take up both these subjects if he hopes to do good work in either one or the other. The attention given to entomology has therefore been very small indeed. But as there is no one at present in a better position to take up this very important branch of agricultural science, it was necessary to give it some time and to deal with the questions as well as the circumstances would permit.

The applications for advice and assistance in fighting insects have been numerous. But as heretofore the attacks have generally been brought to the notice of this Department much too late. Sometimes months have been allowed to pass in which the insect pests wrought their havoc and grew to their full size.

Naturally as these insect pests grew and approached maturity their appetite became greater and the damage they did each day increased also. As mentioned in my Bulletin No. 1 when the larvæ, which generally do the damage to the crop, are full grown they crawl away to some protected spot to pupate. It was generally just before the pests reached this stage that the damage was reported and they disappeared of their own accord before any remedy could be applied. Unfortunately, the insects did not die as is generally believed by the raiyats but they simply passed into another stage of life ready to appear again in full force next season, or possibly two or three seasons later. The idea that the pest is killed by the rains is a very comforting but a *very* mistaken one.

CASTOR PEST.—Last year a report was received that caterpillars were causing great damage to Castor oil plants in Davangere. Immediately instructions were sent to apply Paris Green. In reply to this it was reported that the good rains which had since fallen had killed all the caterpillars and that none could be found to send as samples. This year exactly the same information was received from Davangere through another source with exactly the same results. The attack of the carterpillars was reported too late to apply the Paris Green. The caterpillars had all been "killed" by the late rains before the Paris Green could be applied. The progeny of these caterpillars which were supposed to have been "killed" by the late rains, (because none were seen afterwards either dead or alive) will most likely be ready to partially destroy the next crop of castor in that district

exactly the same as has been done in the past. Insects multiply very fast and if it were not that they have a large number of enemies which destroy a large number of them (often in the pupa or resting stage) they would spread so rapidly that any form of agriculture would be practically impossible. But as I mentioned in the bulletin referred to above, if we assist nature to produce an extra amount of crop for our benefit we should also assist nature to protect these crops from the attacks of insects. We should try to harvest the crops and not permit insect pests to do so if we can avoid it, and though it is difficult to stamp out entirely any one of these insect pests, it is well within our power to materially reduce these attacks, and one of the best means of doing so is to use Paris Green against all leaf-eating insects as recommended in the special bulletin on this subject.

Date Palm Pests.—(*Rhynchophorus ferriugineus & Oryctes rhinoceros*).—Shortly before retiring from the Mysore service Mr. A. S. Kearns sent me specimens of two beetles which attacked date trees on the reserves of the Mysore Abkari Department. The one was a brown beetle of medium size with darker spots and a very long snout so characteristic of this class of beetles that they are commonly known as snout beetles. The other was a somewhat larger dark brown beetle with a peculiar hump on the back. The former belongs to a family famous for the large number of injurious insects it contains. The latter is closely related to the well known "Tumbling bug." In its larval stage the former burrows in the tops of the date palm ultimately killing it if present in sufficient numbers and always injuring it. The only remedy I can suggest is that already mentioned by Mr. Kearns, *viz.*, to burn the trees. Major Alcot, I. M. S., Superintendent, Indian Museum, Calcutta, who kindly identified these beetles, says :—"The beetles you forwarded with your letter No. 195 are the well known palm pests. The snout beetle is Rhynchophorus ferrugineus, Olio. The other is Oroctes rhinoceros, Linn. The only remedy that I can suggest is to cut down and burn all trees which you know to be infected by the larvæ." For the opinion expressed by some that the larvæ are bred in cattle manure there is, I believe, no foundation, and the remedy suggested by them to exclude cattle from date reserves is, so far as I can see, not likely to affect the question one way or the other.

Coffee Pest.—*Green bug (Lecanium viride)*.—At the beginning of this year (1901-02) some letters appeared in the *Madras Mail* and *Planting Opinion* about an insect pest

affecting very extensively the figs used as shade for coffee; and spreading from them to coffee and weeds growing in the neighbourhood. The letters were sent from Santaveri, the choicest coffee-growing district in the State. On visiting the affected district I found that although the pest had been known to occur on a solitary tree in the maidan country not far from the Bababuden hills, it had not been noticed in the coffee of that district before, but had suddenly appeared that year and spread with alarming rapidity. Many of the figs (ficus glomerata) were literally covered with it and some of the branches of these trees had already died back. In the affected area hardly a tree could be found which was free from it. The coffee too was badly affected. Before visiting the affected area I recommended the application of kerosine emulsion. But when realizing the large area which would have to be treated and the height of the affected trees it was evident that such a course would be almost impossible and certainly prohibitive so far as the cost was concerned.

Possibly some practical remedy may suggest itself when it is possible to study the reasons for this sudden increase of the pest in a district in which it had existed to a very limited extent for years. But this can of course only be done by a man who has had special training in the subject and can devote practically all his time to this and similar questions.

A sample was sent to the late Mr. Lionel de Niceville, Entomologist to the Government of India. He was also asked to suggest such remedies as he thought might be efficacious in fighting this pest. As I expected the pest to be the ill-famed "Green bug" and as a considerable sum of money had been spent in the attempt to import lady-birds from Australia in the hope that among these might be some which would feed upon this green bug, and as in my opinion such an experiment had little chance of success, I asked Mr. de Niceville to express his opinion on this point. The following is his reply :—

"In reply to your letter No. 58 of 23rd instant, the scale insects which you have sent me as affecting coffee and its shade tree, are *Lecanium viride*, Green. This scale insect has been known for many years past as a severe pest of coffee. The "mealy bug" appearance of the specimens sent is caused by a white mould, and is not secreted by the insect itself and appears to show itself most in very wet weather."

"As for remedies, I fear that kerosine emulsion is practically the only means of combating this pest, and will be found the cheapest. As for the likelihood of the South Indian

Planters eradicating this pest by the importation of lady-birds, I am not in a position, not having any data to go by, to give an opinion on the subject. I fancy, however, that it is useless to go to Australia for lady-birds, as it is very unlikely, except in the case of some cosmopolitan species, that they will eat the green bug. What is required is to endeavour to find out the original home of this pest, and import the lady-birds which feed upon it there, taking care not to import their parasites as well. The success of *Vedalia cardinalis* in destroying *Icerya purchasi* was due to the original home of both being Australia, from whence the latter was imported into California. Mr. Koeble therefore naturally turned to Australia for a parasite of *Icerya purchasi*. Owing to this experiment being successful, it does not follow that we should, without some good reason, go to Australia for lady-birds as a cure for scale insects which may hail from quite another quarter of the globe.

"*L. viride* is subject to the attacks of several species of lady-birds, parasitic *Hymenoptera*, Sachinid flies, lace-wing flies, etc., in Ceylon. As they, however, are themselves kept in check by their own parasites, they have not proved, as far as I know, to be of any very great use. Without a personal examination on the spot, however, it is difficult to indulge in anything more than surmises."

Ragi Pest.—Several reports have been received of insects attacking the roots of various crops. But as I have not received samples and as the attack had disappeared when I visited Kadur, in which an attack was reported at the time, I am unable to say anything further about the subject than that if insects really attack the roots of ragi and other crops as reported, it will be a difficult matter to find effective remedies.

Coffee Pest. Mealy bug (*Doctyliopus*—?).—The only root insect I have actually seen is a mealy bug affecting coffee in Coorg. The same mealy bug also affects the roots of shade trees and those of some weeds in that State. But its attack is still confined to comparatively limited areas, and although some planters suffering from it consider it to be the worst of all the ills they have to contend with, their neighbours who have escaped thus far make very light of it. It is reported to have been introduced in manure from Mysore territory where it is said to affect ragi crops. But it will be difficult to prove that such is really the case even if it should be found to infest ragi in this State. The insect resembles in general appearance the well known "mealy bug," is

about one-eighth of an inch in length and affects, as stated above, principally the roots of coffee. Occasionally it is seen however on the stem as well. It prefers the young plants to the older ones, and is particularly bad in nurseries and newly transplanted coffee. A specimen taken from some weeds growing in coffee was sent to the late Mr. de Niceville for identification. His reply was as follows :—

"In reply to your letter of the 27th ultimo, I beg to report that on examination of the roots of weeds growing in the coffee plantations in Coorg, you sent me, which you say are attacked by 'mealy bugs' which do great damage to coffee, I found only two or three half-grown females which appear to be species of *Dactyliopus*, and that the material sent is insufficient for closer identification, adult females being required. It is useless and hopeless to suggest any remedy for the pest without some knowledge of its life history, of which I am entirely ignorant. As, however, I trust to be able to visit Southern India shortly, I shall then be able to make investigations regarding this and other pests affecting coffee on the spot."

Paddy Pest (*Cecidomia oryzæ*).—The insect attack to which I have been able to devote most attention during the year was one occurring in Mysore District (T.-Narsipur Taluk) on paddy. It was reported to have almost totally destroyed the paddy on several square miles of country in a locality where paddy field joins paddy field as far as the eye can reach. In reality the attack was not nearly so bad as reported, for although there was a fairly general attack for miles along the main road and although the paddy was totally destroyed in places, yet there was nothing like a total, destruction of the paddy over the area visited, and the same thing will probably hold good for the portion of the affected area lying inland. Still the attack was a very severe one, and the aggregate loss to the raiyats must have been enormous.

The most noticeable feature of the affected paddy was that the stalk had no ear-heads. The stalks were much below the normal height and terminated either abruptly, as though cut off, or were capped by a short withered pointed portion which was the undeveloped part of the stem with the embrio ear-head cut off by the insect before the paddy had begun to "shoot." At the top of the abnormally developed remnant of the stalk it was abnormally closed. This closing somewhat resembled a node but had really nothing to do with these normal partitions in the stem. The stem had no nodes or joints. As might be expected, the affected plants, tillered

or stooled, extensively in their attempt to replace the affected stalks but generally these had also fallen a victim to the pest. Apparently the later sown paddy had suffered most. So far as I had an opportunity of observing it, the fields which had been neglected most in the matter of cultivation and manure were also those which suffered most from the insect pest. It was, so far as I could learn, the first attack of its kind in that locality, though doubtlessly the insect must have existed there to some extent before, to cause such a widespread attack—seven miles in extent—this year. Without making a much more careful investigation of the subject than I have been able to make, it is impossible to say what was the cause of this sudden spread of the insect pest. Many reasons might be suggested, however. I shall mention two of these later on.

The larvæ of the insect, yellowish white maggoty-like creatures, burrow in the stem of the paddy before the internodes have begun to develop, or in other words, before the paddy has begun to "shoot." They are generally found quite close to the crown, the division line between roots and stem. Generally but one maggot is found in the affected stem, though rarely two or even three of them are found in the same stem. They confine their attention to the central portion of the stalk leaving the outside in tact. Though hundreds of affected stems were examined, but two pupae were found. One was evidently destroyed when slitting the stem open, the other was simply the covering from which the mature insect had already escaped. This fact suggested to me that possibly the insect normally pupates outside of the affected stems. The larvae when apparently full grown measured about 3/16th to 1/4th of an inch in length. It was never found in stalks which had made an attempt to "shoot." In a very large number of these nothing at all could be found. The older ones were quite open at the top and had died back to the crown. The younger ones were still green and generally closed at the top, but just below this a hole had been eaten into the side of the stalk from which insects had evidently escaped. In about seventy-five per cent of the youngest and freshest of these green stalks were found a cluster of from 10 to 30 tiny little egg-like bodies (probably pupae) grouped together in an oval shape; and though I was unable to find a membrane covering this cluster of egg-like bodies, I expect they were the pupae of a parasite, feeding in the maggots which affected the paddy and of course killing them. These little egg-like

bodies when hatched produced tiny little black flies, probably one of the *Proctotrupids*. In a few stalks which had not the little opening eaten into it near the top I found some of these tiny black flies, in some of the stems they were dead, while in others they were still alive. The only reference I have been able to find of a similar attack is that given in the Indian Museum Notes of an attack in Behar in 1880 described by Mr. Woodmason. He named the pest provisionally "*Cecidomia Cryzae*," but apparently very little is known about it. A sample was sent to Mr. Lionel de Niceville. He received the sample when ill a few days before being taken to the hospital, in which he died about a week later. I owe him a deep debt of gratitude for all the services he has rendered me in the short time he has been permitted to occupy the position of Entomologist to the Government of India, and cannot deplore too deeply the loss occasioned by his death.

One of the reasons which may be suggested for the sudden appearance of this paddy pest is that last year the water-supply in that locality was very low, as a result the paddy was not irrigated nearly as much as is generally considered necessary, and possibly the insect pest may have had a better opportunity to find safe places in which to pupate. Another reason which might possibly be advanced is that for some reason or other there may have been an epidemic in the parasites mentioned above, and that as a result a comparatively large number of insects escaped destruction the previous year and were ready to lay eggs from which the maggots hatched this year. Should this pest re-occur it certainly ought to be carefully studied by a specialist so as to find means of overcoming the attack. The only remedies I might suggest are to sow the paddy as early as possible and cultivate it and manure it as well as circumstances will permit. Similar remedies have been found effective with the Hessian fly, an insect which apparently resembles this one in some respects.

MANGO PEST.—(*Euroctis lunata*).—In May of this year information was received that an army of insects was attacking mango orchards in the north-eastern part of Tumkur District. They originally confined their attacks to various members of the Accasia family, but after defoliating a large number of these, attacked the mango orchards in force, destroying practically all the fruit and a large portion of the leaves and young shoots as they went from tree to tree. According to the report of the Amildar of Maddagiri about 30 to 50 square miles were infected with this pest. Last

year, though I have heard nothing of it at the time, the attack appears to have been even worse than this year. The only effective remedy I could recommend was to spray the trees with Paris Green. To do this easily and effectively a specially constructed force pump is necessary, and this I was unable to secure in Madras, and having none myself, the only way to apply the Paris Green was to climb the trees and sprinkle it on with an old broom, a very difficult, dangerous and imperfect way. Samples were sent to Mr. Green, Entomologist to the Government of Ceylon, for identification. In reply he wrote :—"The caterpillars are the larvae of *Euroctis lunata*. I doubt if anything but some arsenical preparation sprayed upon the foliage would kill the caterpillars. But the pest might be partially checked by jarring the branches and crushing the fallen caterpillars. When the moths begin to emerge, large numbers of them could probably be destroyed by the use of lamps set in basins containing water with a film of kerosine. Messrs. Vermosel & Co. have constructed a very useful acetylene lamp for this purpose, at a cost of 16 francs (at Marsailles) complete with basin etc."

Conclusion.—An opinion prevails among many that in India agriculturists suffer but little from insect pests. Nothing can be further from the mark than this.

The pests I have mentioned above are only a part of those I have happened to meet during the year, and these are naturally but a small portion of those which actually exist. For example, in certain parts the boll worm practically prohibits cotton growing of any sort. Still if an attempt were made to calculate the damage done by the pests mentioned above, these in themselves would make an enormous total. In the interests of Agriculture I should heartily welcome an Entomologist to these parts of India, in which the services of such a scientist are urgently needed.

Agricultural Experiments.

After three years of observation of the chief requirements of the native agriculturists of Mysore, I still hold the opinion that the most essential of these is a better food supply for their stock, especially during the hot weather. There are large areas of waste lands and village grazing lands on which the raiyats largely depend for fodder for their stock. In very few instances does any native agriculturist provide pasturage on his own fields. As a rule, he prefers to let his cattle subsist on the free pasturage to which he is entitled rather than provide pasturage for them on lands

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on which he has to pay taxes. In addition to the free subsistence allowance for his stock, he hopes to carry away a little manure from these common pasturage grounds with which to enrich his own fields. That under these conditions the pasturage is of the very poorest kind, is only natural. The grasses are rough and coarse and as a rule cover the ground but imperfectly, and on the poorer lands shrubs and thorns occasionally occupy a large portion of the space. Occasionally, even on good lands where the original surface has probably been washed away by rain, the surface now exposed is so hard and baked that nothing can grow on it at all. In some instances these free pasture lands produce, if not grazed, a crop of grass which might be cut for hay. In fact many of the hill tops in the Malnad produce a dense growth of coarse rank grass. But on the average grazing lands the grass is very sparse and the growth slow.

Accustomed to the marvellous change generally produced in America by ploughing up old run down pastures, breaking up the hard and matted surface, converting the tangled mass of wild grass roots to manure and replacing the poor wild varieties of grass by those which have proven themselves much superior, it was natural to suppose that somewhat similar results could be produced here by a like method.

A piece of very fine looking waste land near the laboratory was ploughed up, carefully cultivated, divided into plots 1/200 of an acre in size and seeded down with the following varieties of grasses and clovers:—

	Elymus Canadensis	
	Bromus Schraederi	
	Bromus inermis	from U.S.A.
	Do	England
Orchard grass	...*Dactylis glomerata*	
Tall oat grass	...*Avena elatior*	
Timothy	...*Phleum pratense*	
	Bouteloua oligastachya	
Italian rye grass	...*Lolium Italicum*	
	Lycurus Phleoides	
	Paspalum dilatatum	
Bermuda grass	...*Cynodon Dactylon*	from U.S.A.
		Native

Hariali grass ...	...*Cynodon Dactylon*
Giant hybrid cow clover	...*Trifolium Pratense*
Sutton's perennial red clover ...	*ditto*
Provence lucerne ..	...*Medicago sativa*
American do ...	... *ditto*
Indian do ...	... *ditto*
Turkestan do ...	... *ditto*
Giant Sainfoin ..	...*Onobrychis sativa*
Japan clover ...	...*Lespedeza striata*
Bokhara do ..	... *ditto*

Many of the above seeds were kindly sent me by the Department of Agriculture at Washington, U. S. A. They were specially selected for Mysore where drought resisting tendencies are of special value. Of the remaining seeds most were imported from England. Duplicates and triplicates of many of these plots were made to test different methods of sowing and cultivation. Hariali for example, was sown by seed on one plot, on three others it was reproduced by cuttings. On one of these plots it was laid in the furrows and completely covered by the succeeding furrow. On another plot it was treated in a similar way but a part of the stem remained above ground. On a third plot the hariali grass was cut into lengths of about 2 to 4 inches, was sown broadcast and sand sprinkled over it to keep it in place. All the plots grew finally about equally well, though that sown broadcast on the surface made the easiest start and stood evenest to begin with, next came the plot in which the hariali had been ploughed in but not completely covered, while the plot in which it had been completely covered was the last to show an even stand. The seed did not germinate at all.

In lucerne there are several varieties which are not well known nor well recognized. The lucerne as grown in India is an irrigation crop, while in California, lucerne or Alfalfa as it is called there, is known for its drought-resisting tendencies. In America it is often sown on light sandy soils, and on such soil the roots have been traced to a depth of ten feet and more. As the object of the experiment was to see what could be done with these varieties of grasses and clovers on the ordinary waste lands by good cultivation without manures, of course no manures were applied to these or any of the other plots. The soil was too poor to produce any satisfactory growth on any of the lucerne plots though

irrigated and therefore not suffering for want of water. What little difference there was in growth was in favour of the acclimatized seed. The plot on which the acclimatized clovers was sown was cut four times and produced a little over 51 lbs. on 1/200 part of an acre. The other plots of lucerne of the same size were cut only once at the close of the experiment and produced from 7 lbs. to 10 lbs. each. The soil was very much inclined to form a crust and cake throughout. The poor growth was at first attributed to this peculiarity of the soil. Several duplicate plots were sown, some were dug, some mulched and some limed to overcome this caking tendency. But the poverty of the soil debarred any of these treatments taking any effect. On all the plots the growth was practically at a stand-still when the plants were from 4 to 8 inches high.

The results obtained with most of the other clovers and grasses were even less satisfactory than those described for lucerne, and corroborated the conclusion which may be drawn from the results with that clover, *viz.*, that if the waste lands experimented on represent the bulk of the waste lands throughout the State, cultivation alone will accomplish but little in the way of improving the food supply for stock; that even the introduction of good varieties of grasses will be of little use unless the lands are manured in some way or other. Whether the waste land experimented on is a true representative of its class, requires to be investigated by repeating the experiments in other parts. From its appearance it would rank rather above than below the average. But I sincerely hope that in this case appearance will prove to be deceptive.

In addition to the poverty of the soil, all sorts of diseases and insect pests had to be contended with. There was hardly a plot which did not become diseased more or less sooner or later. This was particularly true of the grasses. Several of the plots were completely wiped out shortly after they had stopped growing, and at the close of the year but few individual specimens of the imported grasses were alive. No doubt the poor soil was largely to blame for these attacks. Attempts were made to identify some of the diseases, but as they were out of the ordinary course of the well known plant diseases, it would have taken a specialist years to investigate them.

The best results among the grasses were undoubtedly obtained from hariali. It completely covered the soil and made some growth as well, so that at the end of the year a

small amount of crop, 5 lbs. or 1,000 lbs. per acre was realized. It too appeared to be affected with a disease, which resembled somewhat in external appearance "rust" on wheat and oats. But when examined microscopically it was found to be totally different. Quite a number of spores were found but they belonged to different families and were evidently not the cause of the disease. Dr. Butler, Cryptogamic Botanist to the Government of India, afterwards identified the supposed disease to be due to the puncture of a tiny gall insect, which had caused botanists a great deal of trouble until investigated by Professor Magnus of Berlin.

The experiments indicate that hariali grass is much easier to grow than is generally believed in India, and will exist on a soil on which many of the other good variety of grasses will perish. If sown during, or just before, the monsoon, it is certainly not necessary in Mysore to go to the great expense of dibbling in the grass, a practice very largely, if not universally, adopted at present. It is not even necessary to mix the cut grass with cattle manure and other substances as sometimes recommended. In fact it is doubtful if that method will answer as well as that in which the cut grass is simply held in position by a little sand. A top dressing of manure is, however, highly desirable. Experiments will, however, have to prove whether it is better to apply this at once or to wait until the grass has taken root.

Several other crops were experimented with on these plots near the laboratory. Among these were horse gram, cow gram, ragi, cholum, ganja vetches, blue lupines and potatoes.

In none of these was any sort of manure used. The vetches germinated well, but apparently did not grow much beyond the stage to which the reserve materials in the seeds sown permitted them to grow. The lupines, however, grew to a height of about 18 inches, but had a sickly appearance all the time, the lower leaves dying as those on top were being formed. The crop when cut weighed a trifle less than 20 lbs. The plot like all the others mentioned before was 1/200 of an acre.

The ganja grew about the same as the lupines. It had a sickly appearance. The stand was very uneven. The male plants were removed, as is usually done, and about 11 oz. of the pressed cake was obtained. The plot was, however, nearly 1/100 of an acre.

The potato plot was 8 times the size of the ordinary plots. To keep off the potato disease it was treated fre-

quently with Bordeaux mixture. Like all the other plots it was regularly cultivated and did not suffer for want of water. Still the yield of potatoes was less than the seed which had been sown.

The stand of all the remaining crops was also very poor, but decidedly better than the poor stand of grass and other crops mentioned above might have led one to believe. The Bengal gram gave a crop of 10 oz. and nearly 1½ lbs. of straw. The total weight of horse gram and straw harvested was 29½ lbs. The ragi had been eaten by birds. The total weight of straw and the little grain left was 9 lbs. The cow gram grew fairly well on a part of the plot. It was cut green and weighed 57 lbs. The cholum had been injured several times by stray cattle, donkeys, etc. The crop of stalks and such ear-heads as were left weighed 32½ lbs. when cut. All the plots were 1/200 of an acre.

The experiments as a whole appear to indicate that the crops usually grown by the raiyats can subsist on very poor land more easily than the grasses and clovers and potatoes tried on the plots this year. They further illustrate that there is something radically wrong with the soil. Possibly it is too poor in composition to produce anything like a medium crop, or possibly the fact that it has been exposed to the tropical sun for years without a crop to protect it, has in some way or other affected its productiveness. But to return to the original object of the experiment, that of the better pasturage for stock, it is very doubtful, as already stated, if cultivation alone will enable the raiyats to supply better pasturage for their stock. It most likely requires the assistance of manures. But as has been pointed out in a previous section of this report, there is every prospect of the raiyat being able to materially increase his supply of manure with a little extra care and energy.

Shade for Coffee.

At the request of some of the leading South Mysore Planters, twelve samples of leaves from some of the best shade trees have been analysed. The leaves were collected and named by Graham Anderson, Esq. C.I.E., and there could be no better guarantee of the samples being true to name. The analyses are not quite complete at present, the potash in several samples not having been determined. Furthermore there ought to be a few samples of leaves from proverbially bad shade for comparison before the results can be intelligently discussed. I therefore simply give the analytical results at present, with the one comment that many

of the leaves contain a higher percentage of nitrogen than might be expected, considering they are those which have dropped from the trees in the natural course of events, when a large portion of the nitrogen is doubtlessly re-absorbed by the tree in the protoplasm which travels back to the stem before the leaves drop.

Experiments with Fertilizers on Coffee.

Twelve plots of coffee were selected on as many different estates for experiments with fertilizers. These experiments have the double object of telling the planter of what kind of plant-food his estate is in greatest need, and of giving some indication as to the kind of plant-food most required by coffee. For, as is well known, some plants require more of one kind of plant-food to be given them, while for other crops it may be advisable to let another kind of plant-food predominate. For example, for most grains, other things being equal, nitrogenous fertilizers respond best, while legumes generally require potash and phosphoric acid most. What coffee requires most on an average soil is quite unknown. The experiments are therefore primarily to test the soil of the estate on which they are carried on and as such are only applicable to the estate on which they are carried on. But the secondary object of finding out some general principles as to the manuring of coffee is of course of general interest and a very important one. In order to be able to get any information on this latter subject, it is necessary to know as thoroughly as possible the composition of the soil on which the experiments were made. As was reported last year, great care was bestowed on the taking of these samples. Two were taken from each plot. one representing the top foot, another the second foot of soil. Each sample was made up of 10 to 25 different borings taken at regular intervals. Unfortunately, several of the planters who had undertaken these experiments discovered afterwards that they were unable to carry them out; and owing to the almost total failure of the coffee crop, those experiments which were carried out are this year practically valueless For, since the cause of the failure of the crop cannot be attributed to the lack of fertility in the soil, the application of fertilizers to the soil can have had very little, if any, effect on the very small crop picked this year. The results of the experiments this year would be misleading if any difference in crop, is attributed to the fertilizers applied. They are therefore not given, and as the analyses of the samples of soils taken from these plots are principally of no value when

Acc. No. 9958.

studying these experiments, they are also omitted, notwithstanding that about half of the work connected with these analyses has been done.

Correspondence.

The total letters received were 762, and those sent 751. Of course, no account would be taken of this part of the work if the correspondence were all of the ordinary office nature. But though a large number of letters are of course connected with ordinary office routine, a large number were answers to questions relating to some one or other branch of agricultural science. The time involved in obtaining the desired information and in answering these letters was by no means insignificant, and of course the work connected therewith had to be done almost entirely by the Agricultural Chemist. Frequently the entire day had to be spent in this work. But though this information is given to individuals and generally relates to some special problem, it is nevertheless cheerfully given ; and as it has the great advantage over general information that it is likely to be acted upon by the persons who receive it ; and as such correspondence has a number of advantages which need not be enumerated here, it is a branch of the work which is considered eminently useful and important. The subject which has been apparently of greatest interest to correspondents has been insect pests and plant diseases. 93 letters were received and sent under this heading. Next comes Chemical Analyses with 92. Next in order are coffee experiments, sugar industry, general agricultural experiments, and fibre industry. Instead of writing for the information they desired, quite a number visited the laboratory and asked for the information they wanted. Of course no account is kept of such inquiries. Among the visitors were several deputations or what appeared to be deputations.

Machines and Implements.

Many of these visitors asked questions relating to the use and probable expense of various farm implements and machines, principally ploughs cultivators and drills and rice-hulling machines. Generally the very smallest and lightest implement which will do the work reasonably effective is desired, though once information about a steam-plough was desired. This was, needless to say, quite unsuited for the existing requirements (small paddy fields). Several inquiries have also been made about sugar machinery and implements. Several visitors desired to know all about the

machinery necessary for a modern sugar house on a small scale. But the capital necessary for such an investment was invariably much more than they had at their disposal. I sincerely hope that shortly I shall be able to have a permanent exhibit of such improved implements and machines as, after being tested, appear to be suited to the requirements of the raiyats and other agriculturists.

Reports, etc.—One report and two bulletins have been printed and sent free of charge to residents of the State who applied for them. One thousand English copies and 5,000 copies of the Kanarese translation have been printed in each case, and of these all but a few hundred copies have been distributed.

A. LEHMANN,
Agricultural Chemist.

Juice of Sugar-cane from Sulikere and Jaggories boiled from it.

Number.	Substance.	Moisture, per cent.	Glucose.		Total solids, per cent.	Soluble ash, per cent.	Soluble carbonates, per cent.	Sucrose, per cent.	Loss of refinable sugar by inversion calculated, per cent.
			Total per cent.	Formed by inversion calculated per cent.					
167	Juice	...	·97	...	17·9	...	...	16·3	..
182	Jaggory	6·13	6·67	1·9	...	2·74	·75	79·7	5·7
168	Juice	...	·98	...	15·6	...	...	14·2	..
183	Jaggory	4·50	11·1	5·9	..	3·56	1·04	74·1	17·7
169	Juice	..	·92	..	17·6	...	...	16·2	...
184	Jaggory	2·95	10·6	6·2	..	2·63	1·02	76·8	18·6
170	Juice	...	·90	...	17·1	...	..	15·8	...
171	Juice	..	·91	..	17·6	...	...	16·2	...
186	Jaggory	3·55	8·70	4·3	...	3·24	1·02	78·4	12·9
172	Juice	...	·72	...	17·7	...	...	16·3	...
187	Jaggory	5·45	13·9	10·9	..	2·99	·96	76·7	32·7
173	Juice	...	·96	...	17·5	...	...	16·0	...
188	Jaggory	9·45	13·5	9·9	...	3·80	1·37	59·2	29·7
175	Juice	...	1·19	...	16·6	...	...	14·3	...
189	Jaggory	4·80	6·25	4·5	...	3·02	1·27	80·1	13·5
176	Juice	...	1·16	...	16·1	...	...	14·9	...
190	Jaggory	6·25	11·10	5·2	...	3·42	·96	75·7	15·6
177	Juice	...	1·10	...	17·6	...	...	15·7	...
178	Juice	...	1·02	...	17·5	...	...	15·8	...
179	Juice	...	1·00	...	17·4	...	...	16·1	...
193	Jaggory	3·82	10·6	5·9	..	3·20	·93	75·0	17·7
180	Juice	..	·76	...	17·2	...	...	14·8	...
194	Jaggory	5·42	12·50	9·2	...	2·95	·95	65·6	27·6
181	Juice	...	1·04	...	17·2	...	..	15·8	...
195	Jaggory	9·57	15·6	11·0		3·38	1·20	70·0	33·0

Juice from Sugar Beets (Austrian) Sown August, 15th, 1901.

Number	Age of beets in days	Weight of leaves in grammes	Weight of beets in grammes	Total solids	Sucrose	Coefficient of purity	Remarks
...	...	...	...	...	3·7	..	
164	94	642	344	9·9	7 6	77	
164 (*a*)	118	304	478	10·4	7·0	67	
165	228	146	496	18·3	14·7	80	

Juice from Sugar Cane and Jaggory from Saklespur.

Number	Substance	Glucose	Total solids	Sucrose	Remarks
196	Juice	5·55	22·6	16·7	The cane had been cut 15 days before it reached laboratory, and looked shrivelled up.
197	Jaggory	11·8	...	78·2	

Analyses of Ripe Leaves from Hassan District collected after they had fallen.

No.	Local name of Tree	Botanical name of Tree	Nitrogen %	Phosphoric acid %	Insoluble Residues %	Iron and Aluminium Oxides %	Lime %	Moisture, Organic and Volatile matters (approximate) %	Remarks
36	Gonee ..	Ficus Mysoriensis ...	0·821	0·155	4·62	1·08	5·29	96	The names of the trees are given in the order of merit for shade for coffee as selected by a Committee of Planters in Saklespur. The leaves were collected and named by Graham Anderson, Esq., C. I. E., of Barguai estate.
37	Kare Busree ..	Ficus infectoria ...	0·932	0·157	6·46	0·87	5·11	82	
38	Cub-Busree ...	Ficus ...	0·811	0·151	6·76	0·38	3·01	87	
39	Attee ...	Ficus glomerata ...	0·915	0·163	8·38	0·71	5·57	78	
40	Beete ...	Dalbergia latifolia ...	1·597	0·225	1·64	0·99	1·77	93	
41	Jack ...	Atrocarpus integrifolia	1·067	0·112	8·67	0·65	2·77	85	
42	Mullay Gerguttee...	Ficus ...	0·838	0·115	12·54	0·76	5·45	76	
43	Wartee ...		1·07	0·137	7·64	1·16	..	86	
44	Whotungay ...	Albizzia ...	1·79	0·266	3·68	1·45	...	91	
45	Tare ...	Terminalia belerica ..	0·654	0·127	6·95	0·53	...	86	
46	Govarnellu ..	Bischofia Javanica ...	0·79	0·221	3·66	1·05	...	91	
47	Silver Oak ...	Grevillea robusta ...	0·76	0·077	0·59	0·38	...	94	

Analyses of Fish, Bone, Poonacs, Dried Blood and Prawn Manure.

No.	Substance.	Locality.	Nitrogen.	Phosphoric acid.	Moisture.	Insoluble Residue.	Organic and volatile matter.	Remarks.
2	Fish, dried whole ...	West Coast ...	3·96	1·73	28·00	2·71	44·51	
5	Do do ...	Do ...	7·61	5·42	5·59	3·48	71·02	
6	Do do milled ...	Do ...	6·98	4·75	4·06	7·40	65·54	
7	Do do ...	Do ...	8·72	6·12	4·41	9·73	70·21	
8	Do skins do ...	Do ...	12·00	3·37	...	...	...	
9	Prawn skins ...	Do ...	8·14	..	...	4·47	78·46*	
1	Dried blood ...	Bangalore ..	11·55	...	...	...	...	
3	Castor poonac ...	Do ..	7·38	...	...	...	...	
10	Hongay poonac ...	West Coast ...	3·82	...	...	...	..	
11	Bone meal ...	Bombay ..	2·52	18·62	...	13·01	31·3	
15	Bone meal ...	Bangalore ...	4·04	23·34	..	2·03	39·42	

*Moisture and volatile matter.

Miscellaneous substances.

No.	Substance.	From.	Moisture.	Organic and volatile matters.	Nitrogen.	Insoluble Residue.	Iron and Aluminium oxides.	Lime.	Phosphoric acid.	Potash.	Remarks.
32	Ashes ...	Central Distillery, Bangalore.	4·53	28·94	...	24·40	7 56	29·04	1·45	1·97	Partially leached.
25	Limestone ...	Kadur District ...	0·84	..	..	7·34	3·04	48·66	...	...	
26	Lime ...	Do do ...	0·87	...	...	21·46	7·75	41·58	...	...	Used for manurial purposes.
28	Lime ..	Do do ...	0·96	...	...	27·94	4·41	37·45	...	..	Do
27	Tank soil ...	Oossur Estate, Hassan District.	9·09	55·11	1·26	24·98	11·47	0·64	0·14	...	

DEPARTMENT OF AGRICULTURE,
MYSORE STATE.

FOURTH ANNUAL REPORT

OF THE

AGRICULTURAL CHEMIST

FOR THE YEAR 1902-1903.

Kanarese and English Reports and Bulletins of the Department of Agriculture will be sent free to Planters, or Raiyats, who apply for them, so long as the supply lasts.

BANGALORE:

MYSORE GOVERNMENT CENTRAL PRESS

1904.

FOURTH ANNUAL REPORT OF THE AGRICULTURAL CHEMIST FOR THE YEAR 1902-03.

PART II.

11. Part I (paras 1-10) of this Report which bears on the general working of this Department is not intended for distribution. Part II contains results of plot experiments, gives the composition of various soils, fertilizers, coffees, oils and water analysed during the year. It gives also a few notes on entomology and a short report on a rice-huller.

Plot Experiments.

A. In the Laboratory Compound.

12. The experiments in the Laboratory compound were continued this year even though the ground is not well suited for the work. The difficulty experienced in keeping out stray cattle also hampers the work considerably. Some of the grass plots were injured by them and the sugar-cane has been pulled about. This defect is, however, to be remedied soon by the building of a permanent enclosure.

13. *Grasses and Clovers.*—A fresh lot of drought-resisting grasses were kindly sent by the Department of Agriculture at Washington, and were sown on July 4th on plots which had received a liberal dressing of manure. But on the whole the grasses fared not much better than last year. Most of them died out after reaching a height of from 4 to 8 inches. The white-ants killed some of them. Below is given a list of grasses sown. The plots were all one-two-hundredth of an acre and had received at the rate of 200 lbs. of phosphoric acid and 100 lbs. of nitrogen per acre. Half of each plot received a dressing of 36 lbs. of potash as well. The only plot on which this addition of potash showed any marked result was on the

lucerne plot. On it the portion which had received the 36 lbs. of potash produced a little over double the weight. That which had received only the phosphatic manure and nitrogen gave a little less than 20 tons of lucerne in a year, while the 36 lbs. of potash produced nearly 40 tons per year. An additional outlay of about Rs. 5 per acre gave an increase of nearly 20 tons of lucerne. But on none of the other plots was the growth of crop sufficiently vigorous to make a marked difference between the portion which had been manured with potash and that without potash manures. The only other plots which made a satisfactory growth were the lupines which produced at the rate of 12 tons of crop per acre in one cutting and the hariali which gave in one cutting $6\frac{1}{2}$ tons. The lupines made of course no further growth and the hariali produced all told at the rate of about 8 tons per acre. The only other plots which produced any kind of growth were the following:—

Table I.

Plot.	Name of grass.	Weight of green grass cut, calculated, tons per acre.	Green grass, lbs. per plot.
6	Sporobolus Wrightii ...	$1\frac{3}{4}$	21
7	Panicum bulbosum ..	$6\frac{3}{4}$	$74\frac{3}{4}$
8	Panicum Texanum ...	$4\frac{1}{2}$	$51\frac{1}{4}$
9	Astrebla pechnacea ...	$1\frac{1}{2}$	$17\frac{1}{2}$
12	Poa compressa ...	$2\frac{1}{4}$	$25\frac{3}{4}$
15	Chatlochloa Italica ..	1	12

14. All the other grasses and clovers with the exception of lucerne, hariali and lupines mentioned above either did not germinate, died out or did not grow sufficiently to make them worth while cutting. Those which did not germinate were: —

Sporobolus cryptandrus,
Hilaria cenchroides,
Bouteloua polystachya,
Do hirsuta,
Do oligostachya,
Atriplex halimoides,
Do truncata,
Do holocarpa,
Dactyloctenium Australiense.

15. The grasses, clovers and fodder crops which germinated but died before being cut were the following. Nearly all of them lingered for a long time before dying gradually. The dates given in the table below are therefore only approximate :—

Table II.

No.	Name.	Height in inches.	When dead.
A 1	Elymus Canadensis	3 to 4	9th January 1903.
2	Do Virginicus	2 to 3	Do
3	Do glabrifolius	2 to 3	Do
4	Sporobolus airoides	5 to 8	12th October 1902.
16	Dactylis glomerata	4	18th May 1903.
17	Lolium Italicum	8	16th October 1902.
18	Phleum pratense	2 to 3	4th February 1903
B. 7	Agropyron tenerum	5	21st October 1903.
8	Do occidentale ..	3	13th November 1902.
9	Bromus inermis (American) ...	8	16th January 1903.
11	Do Schraderi	7	Do
12	Do inermis (Sutton's) ...	3 to 4	Do
13	Avena elatior	6 to 7	Ploughed in on 7th July 1903.
14	Perennial red clover ...	3 to 5	18th May 1903.
15	Alsike clover	5 to 6	Do
17	Kidney vetch	2 to 3	9th March 1903.
19	Giant sainfoin	4	20th March 1903.

No. A.17 grew nicely at first but was killed by white-ants.

16. On 13th July 1903 all but a few of the grass plots were ploughed up, manured and sown with ragi. An attempt will be made to acclimatise those varieties which

have done at all well by growing them from seed grown on the experimental plots.

17. *Sugar-cane.*—Some preliminary experiments were started with sugar-cane in the Laboratory compound. The manuring was uniform throughout; 270 lbs. of nitrogen, 250 lbs. of phosphoric acid and 150 lbs. of potash were supplied per acre. The object of the experiment was to try irrigation in trenches, 2½ feet deep, at varying distances from each other instead of allowing the water to flow over the surface as is usually done. The advantage the trench irrigation was expected to give was to prevent the puddling and caking of the surface which is the inevitable result of surface irrigation on many kinds of soil. The sub-soil in the Laboratory compound was too porous however to admit of this method of irrigation being a success. The experiment will be repeated on the experimental farm when established. Another experiment tried was deep digging *versus* ordinary cultivation. The sugar-cane on the deeply dug plots was much larger and more vigorous during the early part of the experiment. Some varieties are also being tried. But none of these experiments can be reported until next year after the crop has been harvested.

B. On Coffee Estates.

18. As mentioned on page 30 of the 3rd Annual Report of this Department, some fertilizer experiments with coffee were begun some years ago. These were not the first experiments made in Mysore, for practically ever since commercial fertilizers have been used the results obtained on one field have been compared with the results obtained with another fertilizer on another field. In these earlier experiments some of the fundamental principles of field experiments have, however, been neglected.

19. When conducting agricultural experiments, we of course judge the results of the experiments by the difference in crop produced. For example, if we want to find out the effect digging has, we compare the crop produced on a dug plot with that grown on a plot which has not been dug. Similarly, if we want to make manurial experiments we compare the crops from a manured plot with that from

an unmanured plot. If we both dig and manure one plot we cannot find out what effect either of these operations has had on the crop produced if we compare this crop with one grown on a field which has been neither dug nor manured. The difference in crop may be due to either the digging or the manuring or to both. Or one or other of these operations may have been injurious by itself and the other may have partially made up for this injury, or overbalanced it. It is evident that an experiment like this is absolutely useless for finding out the effect of either digging or manuring. This example teaches us one of the fundamental principles of agricultural experiments, *viz., all the factors which may affect the growth of the crop must be the same in the plots under one experiment, except of course the one factor which forms the basis of the experiment.* But the factors which effect the growth of our crops are very numerous. Those embraced by the term chemical and mechanical condition of the soil are very large in themselves. Added to these are the influence of sunshine and rain, the host of beneficial or injurious bacteria or fungi, the influence of weeds or other plants growing with or near the crop; even the wind has an influence on the growth of some plants. To make an experiment trustworthy we must make sure that all these factors are the same in the various plots experimented with, and remain the same, excepting the one factor experimented with, throughout the experiment. Of course this is practically impossible as many of the factors are beyond our control; and this being impossible, accounts for field experiments, even when carefully conducted, often giving contradictory results. But if we strive to have the factors which do not enter into the experiment, as uniform as possible, and repeat the experiment a large number of times, we often get very valuable, even if not absolutely accurate, results. In the earlier experiments with fertilizers on coffee, the principle mentioned above has not been sufficiently recognised. For one thing, the soil of one field was not quite the same as the soil on the other field used for comparison. It is surprising how quickly the soil varies in Mysore, even in places where it appears uniform to a casual observer.

20. The first step in starting the experiments referred to above was therefore to select a piece of land as uniform as possible, having uniform shade and uniform coffee growing on it. This in itself was a very much more difficult task than might be supposed. Other factors such as the slope of the field and the direction of the rows of coffee had also to be considered. Finally, 12 experimental fields were selected on as many different estates in various parts of the coffee district. These fields were subdivided into various plots, the number of these plots varied as circumstances required from 4 to 18. The nature of the experiments varied also. On some of the fields various forms of phosphatic fertilizers, such as bone meal, basic slag and superphosphates were compared with each other to see in what form coffee was best able to assimilate phosphoric acid. In these experiments the other ingredients of plant food have of course to be given also, so that the coffee does not suffer for want of these. Other experiments were conducted for determining the particular ingredient of plant food which was lacking in the soil, so far as coffee was concerned. Below are given the results of these experiments so far as reported up to date.

Table III.—Experimental Field No. I.—Plots about $\frac{1}{20}$ of an acre.

Plot No.	Fertilizer applied, lbs. per acre.	Plant food applied per acre.			Crop picked per plot of berry			
		Nitrogen.	Phosphoric acid.	Potash.	1900-01.	1901-02.	1902-03.	Average.
1	Ashes 2000	...	10	80	80½	204	112	132
2	Lime 2000				62	216	122	133
3	Poonac 1300 Basic slag 420	51	97	...	21½	172	96	96½
4	Poonac 1300 Ashes 2000	51	27	80	42	192	105	113
5	Ashes 2000 Basic slag 420	...	97	80	63	143½	112	106
6	Nothing	...	..	...	67½	248	154	156½
7	Poonac 1300 Ashes 2030 Basic slag 370	51	97	80	22½	219½	80	107
8	Poonac 1300 Ashes 2000 Basicslag 3701 Lime 2000	51	97	80	49½	304	124	159

Table IV.—Experimenal Field No. II.—Plots about $\frac{1}{10}$ of an acre.

Plot No.	Fertilizer applied, lbs. per acre.		Plant food supplied per acre, lbs.			Crop picked, lbs. per plot of cherry.		
			Nitrogen.	Phosphoric acid.	Potash.	1901-02.	1902-03.	Average.
9	Basic slag	300 ...	38	81	87	58	449	203½
	Poonac	700 ...						
	Ashes	2000 ...						
5	Basic slag	420 ...	...	80	...	57½	713	285½
3	Superphosphate	300 ...	38	81	87	51	626	338½
	Poonac	700 ...						
	Ashes	2000 ...						
7	Bone	300 ...	39	83	85	49	512	280½
	Poonac	700 ...						
	Ashes	2000 ...						
6	Lime	2000 ...	...	...	...	47	551	299
4	Nothing	... ...	...	...	...	46½	709	377½
2	Superphosphate	300 ...	38	71	85	46	640	338
	Poonac	700 ...						
	Muriate of Potash	160 ...						
10	Nothing	... ...	...	...	...	35	461	248
8	Poonac	700 ...	38	10	89	34	554	294
	Ashes	2000 ...						
1	Nothing	... ...	...	...	...	30	597	313½

Table V.—Experiment Field No. III.—Plots about $\frac{1}{10}$ of an acre.

Plot No.	Fertilizer, lbs. per acre.	Plant food per acre.			Crop, green cherry, lbs. per plot, 1902-03.
		Nitrogen.	Phosphoric acid.	Potash.	
1	Ashes 2000 ... / Poonac 700 ...	38	10	87	381
2	Ashes 2000 ... / Poonac 500 ... / Bone meal 300 ...	39	83	85	520
3	Nothing ...	...	...	...	610
4	Ashes 2000 ... / Poonac 700 ... / Basic slag 300 ...	38	81	87	459
5	Lime 2000 ...	.	...	...	289
6	Nothing ...	..	...	..	333
7	Ashes 2000 ... / Poonac 700 ... / Superphosphate 300 ...	38	81	87	360

Table VI.—Composition of Surface soil (1st foot) and sub-soil (2nd foot) on Experimental fields, Nos. I, II and III.

Air-dried samples.

	Field No. I.		Field No. II.		Field No III.
	Surface soil.	Sub-soil	Surface soil.	Sub-soil.	Surface soil.
Moisture	3·07	2·68	2·06	1·65	2·33
Loss on Ignition ...	12·30	10·09	8·58	6·77	8·83
Insoluble Residue ...	53·59	54·24	75·66	76·57	72·11
Nitrogen	0·18	0·11	0·19	0·11	0·18
Oxide of Iron ...	16·27	17·12	3·61	4·14	4·54
Oxide of Alumina ...	13·16	14·41	9·34	9·93	10·79
Lime	0·50	0·29	0·28	0·17	0·70
Phosphoric acid ...	0·10	0·10	0·07	0·06	0·06
Potash	0·17	0·18	0·23	0·24	0·26

21. Considering the care with which the plots were selected, the above results are rather surprising. They indicate that some factor or factors of plant growth other than the manures applied must also have varied. And as in both fields, No. 2 and No. 3, one of the "no manure" plots has given practically the highest and the other the lowest returns, it would appear as though these changes produced by the unknown factors affecting the cropping of coffee had been greater than the changes made by the manures applied. But before any thing more definite can be said on the subject more experiments will have to be conducted. Though the results appear very discouraging and contradictory, they will, if confirmed, be really very valuable as they will teach us the necessity of making experiments in other directions when studying the cropping of coffee.

Laboratory Experiments.

A. Quality of Coffee.

22. The quality of the coffee produced is no doubt a factor of even greater moment to the planter than the quantity. This fact has been forcibly illustrated during the past years. In order to improve the quality we must, however, have a standard of quality. The old standard was simply the *appearance* of the bean. Now the "liquoring" of coffee is introduced. But neither of these standards is as accurate as might be desired. Both depend exclusively on what is called the "personal element," a factor which ought to be excluded as much as possible from all standards as it varies with different persons or even with the same person when in different states of health. Moreover it does not admit of being accurately recorded and it is therefore difficult, if not impossible, to compare the quality of one year's crop with that of another year. But up to the present no more reliable method of judging quality is available.

23. We do not yet know on what constituent or constituents of coffee its quality really depends. That it does not solely depend on caffeine is evident from the fact

that this alkaloid is identical with the alkaloid which was popularly supposed to give tea its peculiar flavour. As we do not know the constituent which gives coffee its quality, it is of course out of the question to attempt to determine it quantitatively. But assuming that some constituents in plants are likely to occur in a more or less fixed ratio to each other, especially in the seeds, it may not be impossible to find that some constituent which in itself has nothing directly to do with quality, might nevertheless be an index of quality; because the substances which actually give quality are associated with it in a fairly constant ratio.

24. On the strength of this supposition some characteristic samples of coffee which were kindly sent me by the Manager of Messrs. Binny & Co.'s Coffee Works here, were partially analysed. The results are as follows :—

Table VII.

Number.	Specific Gravity	Moisture	Nitrogen.	Loss on Ignition	Lime.	Phosphoric acid.	Potash	Price.
1	2	3	4	5	6	7	8	9
49	1·268	4·49	2·45	91·49	·196	·43	1·94	80
63	1·267	4·23	2·20	91·59	·187	·43	...	77
67	1·258	6·24	2·18	89·91	·169	·41	1·92	60
66	1·259	10·01	2·12	86·24	·177	·39	1·78	59
65	1·250	3·84	2·20	92·11	·16	·41	1·95	59
*65a	...	6·00	2·15	89·81	...	·40	1·90	...

* The same as No. 65 calculated to the water content of No. 67.

25. In the hope that the density of the bean and its nitrogen contents might possibly be an index of quality, these were determined first. The price obtained for these samples on the London Market was taken to be the best index of quality available at the time. This is given in column 9 and the samples are arranged according to it. By comparing the specific gravities as given in column 2 with the prices realized, it will be noted that with one exception the heavier the bean the better the price paid for it. The same holds good as regard the nitrogen contents.

Tho only exception No. 65 was very much drier and when calculated to the same water contents as No. 67, it will be seen that this exception disappears. The same is practically true of phosphoric acid and potash. So far as the results go they are very satisfactory indeed. But the number of analyses is much too limited to warrant drawing any conclusions. Of all the figures given above the specific gravity is most quickly and most easily determined. But some more serviceable liquid than water will have to be found in which to determine it. If done too rapidly in water, air bubbles are liable to cling to the coffee and the specific gravity determined is too low. If done too slowly, the coffee begins to swell and loses in specific gravity. The determinations above were made with the Westphal balance with 50 grams of coffee and the highest specific gravity was recorded in each case. The work will be continued next year if suitable samples can be secured.

B. Foxiness in Coffee.

26. When determining the specific gravity of the coffee during some analyses made in the Laboratory, it was noticed that all the samples which had been dipped into water and dried afterwards had become foxy. Foxiness is due to the outer covering especially the silverskin being dyed brown by a water soluble colouring matter found in cured coffee. The remedy is therefore to dry the bean before this colouring matter is formed, as otherwise this colouring matter will be brought to the surface on subsequent drying. This colouring matter which turns to a deep pea green when treated with ammonium hydrate, is probably developed after the cherry has ripened.

C. Analyses of Soils.

27. Below are given the analyses of 19 samples of solls from various parts of the Hassan and Kadur Districts. The samples with an odd number in column 1 of the foliowing table are those taken from the first foot of soil and those marked with an even number were taken from the second foot of soil just below the point from which the

preceding sample was taken. These samples were taken from 10 to 25 different equidistant parts of the field by means of an auger. Special precautions were taken to get all and nothing but the portion actually bored out.

Table VIII—Samples of Air-dried Soils.

No.	Samples. Depth.	Locality.	Moisture.	Loss on Ignition.	Insoluble Residue.	Nitrogen.	Ferric Oxide.	Alumina.	Lime.	Phosphoric acid.	Potash.	Magnesia.
59	1st Foot ...	Kadur District ...	4·18	14·19	48·84	·254	15·68	14·10	·45	...	...	...
60	2nd ...	Do do ...	...	...	49·91	·146	16·98	...	·20	...	...	...
61	1st ...	Hassan do ...	...	...	68·36	·187	8·02	10·12	·47	...	...	...
62	2nd ...	Do do ...	2·81	8·26	67·37	·121	8·27	11·87	·38	·067	·40	·38
63	1st ...	Do do ...	2·33	8·83	72·11	·178	4·54	10·79	·70	·063	·26	·59
65	1st ...	Do do ...	2·05	7·27	75·21	·154	4·79	9·36	·39	·038	·31	·49
66	2nd ...	Do do ...	2·13	6·38	73·79	·097	5·36	11·16	·26	·027	·31	·24
67	1st ...	Kadur do ...	3·02	13·73	55·75	·223	10·04	16·65	·23	·10	·15	·41
68	2nd ...	Do do ...	2·76	12·47	54·23	·126	10·10	19·95	·14	·08	·15	·41
69	1st ...	Hassan do ...	2·06	8·58	75·66	·194	3·61	9·34	·28	·068	·23	...
70	2nd ...	Do do ...	1·65	6·77	76·57	·107	4·14	9·93	·17	·057	·24	...
71	1st ...	Kadur do ...	3·07	12·30	53·59	·182	16·27	13·16	·50	·10	·17	...
72	2nd ...	Do do ...	2·68	10·09	54·24	·107	17·12	14·41	·29	·10	·18	...
73	1st ...	Do do ...	1·70	7·03	78·73	·165	3·52	7·72	·30	·04	·31	·44
74	2nd ...	Do do ...	1·57	5·72	78·43	·081	3·74	9·45	·21	·028	·32	·38
75	1st ...	Do do ...	4·14	15·78	45·50	·303	16·42	16·65	·39	·11	·26	·59
76	2nd ...	Do do ...	4·08	13·26	46·97	·215	17·16	17·17	·22	·11	·28	·49
77	1st ...	Do do ...	3·55	11·34	53·79	·278	21·42	8·18	·24	·15	·41	·60
78	2nd ...	Do do ...	3·49	8·72	56·52	·203	20·35	9·37	·20	·11	·27	·69

28. The analyses were made according to the official methods of the Agricultural Chemists of the United States of America. In nearly all the samples the phosphoric acid is below the quantity generally considered necessary for the growth of average crops. The only exception is soil No. 77. The same soil also contains the largest percentage of iron. In most of the soils the percentage of lime is also rather low. Nitrogen and potash are, however, present in sufficient quantities in most of the samples for immediate requirements of average crop. It would be very interesting to know how much of the phosphoric acid and potash are soluble in a 1% citric acid solution, and how much of the loss on ignition is due to the combustion of carbon. A knowledge of the amount of carbonic acid present in the various soils would also be of value. But unfortunately lack of time has prevented making all these determinations up to the present.

29. Comparing the first foot of soil with that just below it, we find that the first foot invariably contains considerably more nitrogen and lime than that below it; and that there is comparatively little difference between the samples from the first and from the second foot so far as the phosphoric acid and potash are concerned. The percentage of phosphoric acid is in each case slightly lower in the second foot, while the percentage of potash is in some cases slightly higher. Both iron and alumina increase in the second foot and the moisture and other volatile matter decrease as might be expected. All these soils have been cropped with coffee for some years. Yet except for the organic matter (which has naturally decomposed much more quickly under cultivation than it would have done if the soil had remained undisturbed) these soils may be considered as practically virgin. They are well shaded and, as a rule, considerably more plant food has been supplied in the fertilizer than has been removed in the crop. This no doubt accounts for the fact that notwithstanding the very low percentage of phosphoric acid they have produced good crops. All these samples were taken from various experimental fields on which it was intended to conduct manurial experiments with coffee.

D—Poonacs.

30. Below is given a table giving the Nitrogen contents of various poonacs analysed during the year :—

Table IX—Analyses of Poonacs.

No.	Substance.	Moisture and loss on Ignition.	Insoluble residue.	Nitrogen	Phosphoric acid.
1	2	3	4	5	6
14	White castor ...	92·19	2·50	6·52	2·34
14b	Do ..	.. ..	... ..	8·69	.....
18	Neem ...	...	.....	4·43	.....
23	Do ...	.....	.....	4·88	.....
24	Do ...	.....	.....	4·62	... ..
48	Do ...	.....	.....	5·13	.....
13	Honge ...	93·49	2·81	4·01	·84
10	Do . .	.....	.. ...	3·82	.....
49	Ippe, light ...	.....	.....	4·01	.....
50	Do dark ...	.....	.....	1·92	.....
51	Do ...	.....	.....	1·80	.....
40	Kurdie ...	96·45	·63	3·22	1·08
22	Do ...	.. ..	.....	6·43	.....

31. Quite apart from adulteration poonacs of the same kind are liable to vary considerably. White castor poonac, for example, grown in Bengal contains, according to Dr. Leather's results, on an average nearly twice as

much nitrogen as that met with in Bombay. This is possibly due to difference in variety. The samples of white castor poonac analysed in this Laboratory resemble much more those of Bengal than those of Bombay. No. 14 given in above table is about the average of those analysed, though one sample reported on last year contained 7·38% of nitrogen. Unfortunately owing to the much larger demand for white castor during the past years, considerable adulteration is said to be practised by the producers. The practice is to again mix with the decorticated seed before extracting the oil a portion of the black husks removed by decortication. The influence this practice has on the quality of the cake or poonac may be judged by comparing samples No. 14 and No. 14b with each other. Sample No. 14 is an ordinary sample of white castor still containing some of the black husks but not intentionally adulterated with this refuse material. Sample No. 14b was prepared by taking a portion of sample 14, after it had been finely ground, and passing it through a fine sieve. The husk being harder a large portion of it had not been ground quite as fine as the soft tissues of the castor bean. A portion of these husks were therefore sifted out and No. 14b is therefore nothing but a more thoroughly decorticated sample of castor poonac than No. 14. The latter may therefore be considered as being unintentionally mixed with husk and as such to be an adulterated sample of white castor poonac. If No. 14b is worth Rs. 80 per ton No. 14 is worth less than Rs. 60 per ton. When this unintentional admixture of husks depresses the value of the castor cake by more than Rs. 20 per ton, it is not difficult to realize that the intentional admixture of the husk is a very serious form of adulteration. The percentage of the husk and its composition have not been determined. The object for the preparation and analysis of sample No. 14b was primarily to illustrate the fundamental principles to be observed when taking and preparing samples for analysis, but it illustrates the effect of adulteration almost equally well.

32. The composition of the Neem poonac reported above varies from 4·43% to 5·13% of nitrogen. If a white

castor having the composition of sample No. 14 is worth Rs. 60, the price it was sold for in Bangalore, sample No. 18 would be worth about Rs. 40 per ton and sample No. 48 would be worth nearly Rs. 47, or nearly Rs. 7 more than sample No. 18, a difference of about 17%. This is of course exclusive of any cost of transportation. The difference in the value of the Ippe poonac analysed this year is much more striking than the differences found in any of the other poonacs. In this instance a distinct difference in variety is, however, indicated by the difference in colour. The light coloured sample is equal in value to Honge poonac No. 13, while both of the dark coloured samples are worth less than half the light coloured sample of Ippe poonac. Sample No. 10 reported on last year is inserted in the above table to indicate that the composition of Honge poonac like that of other poonacs is liable to vary. Both of the analyses of Kurdie poonac, which are borrowed from next year's report, indicate the same thing and give some idea of the composition of recently produced poonacs of this class.

33. When judging the value of a poonac, the principal thing to be considered is its nitrogen contents. The quantity of phosphoric acid and potash may generally be neglected. The value of these constituents compared with nitrogen is so small that it is generally left out of the calculation when comparing the value of poonacs. The moisture, loss on ignition and insoluble residue are factors which the purchaser of the poonac need not consider at all. Even when these are included the analysis is not complete, many substances having been left out. The nitrogen given in the table is organic matter and as such is included among the substances given in column 3 of the above table. The figures are therefore not supposed to add up to 100.

E. Cattle Manure.

34. One of the very important subjects to be considered in connection with the improvements of Agriculture for India is no doubt the preservation of cattle manure.

In last year's report this subject has been discussed at some length (pages 9 to 12). Unfortunately the analyses of the two samples of cattle manure were omitted from the analytical results in the appendix of that report. They are therefore given below together with some other samples of cattle manure :—

Table X.—Composition of Various Cattle Manures.

No.	Locality.	Moisture	Loss on Ignition.	Insoluble residue.	Nitrogen.	Oxide of iron and alumina.
34	Hassan	17·27	27·79	47·22	1·06	5.47
35	Hassan	16·70	17.80	53·54	·64	6·44
78	Bangalore	5·80	33·20	51·00	·77	...
63	Europe	20·00	...	...	5·29	...
65	Europe	20·00	...	..	1·55	...
403	Europe (Urine)	89·79	...	...	·78	...
8	Europe (Fæces)	83·00	...	...	·33	...

No	Locality.	Phosphoric acid.	Potash.	Lime.	Relative value.	Remarks.
34	Hassan ...	·54	·46	1·07	14	27·5 per cent of gravel sifted out before analysis.
35	Hassan ...	·30	·45	·65	8¾	23·9 per cent of gravel sifted out before analysis.
78	Bangalore ...	...	·41	1·35	...	
63	Europe ..	1·30	1·70	...	64	Calculated to 20 per cent water contents.
65	Europe ...	·90	1·44	...	23	
403	Europe (Urine) ...	trace.	1·57	...	...	
8	Europe (Fæces) ...	·24	·14	...	...	

35. All the samples excepting No. 403 and No. 8 are analysed in or calculated to a partially air-dried condition,

and with the exception of No. 78 contain very similar quantities of moisture, so that they can be readily compared one with the other. In column No. 13 is given the relative values of these manures, and a glance at the figures of that column will indicate how widely these manures vary in value. Nos. 63 and 65 are samples of European cattle manure analysed in Europe. The former is a sample which is above the average of ordinary well prepared European cattle manure, while the latter is rather below the average. But even this poorer quality is infinitely superior to the best sample of Indian cattle manure analysed in this Laboratory, and when sample No. 34 is compared with other Indian cattle manure, it will be found to be much above the average. As pointed out in last year's report, the quality of the manure necessarily depends largely on the food given to the animals; but quite as much on the treatment of the manure afterwards. The saving of the urine is the first thing to be aimed at. At present this valuable part of the manure is almost, if not entirely, lost in Mysore. The composition of the urine and solid excreta varies materially, but by comparing No. 403 with No. 8 in the above table some idea of the relative value of these two substances may be obtained. The relative quantity of these two component parts of manure also varies, but it is safe to assume that at least one-half of the value of the manure is lost when the urine is allowed to go waste.

F. Bone and Fish Manure.

36. In the table given below, sample No. 21 is an ordinary bone meal, while No. 22 is a sample of steamed bone meal. In calculating the relative value no account has been taken of the fact that the steamed bone may be more readily available on account of fat having been removed, because the relative availability of ordinary and steamed bone meal has not been tested in a climate like that of Mysore. From observations made on coffee estates in India and the experiments made by Kellner in Japan, it appears probable that bone meal becomes much more rapidly available in India than in Europe. If that is the case the advantage of

steaming bone meal is likely not nearly so great as in Europe, and until actual comparative experiments have been made with steamed and ordinary bone meal it would not be safe to assume that the steaming makes an appreciable difference in the value of the phosphoric acid in bone meal. Both the samples of fish are abnormal in the large amount of insoluble matter (sand) which they contain. Normally the fish manure should not contain more than 10 per cent of insoluble residue. Carefully dried samples contain less than 10 per cent.

Table XI.—Composition of Bone and Fish Manure.

No.	Substance.	Moisture.	Loss on Ignition	Insoluble residue.	Nitrogen	Phosphoric acid.	Approximate relative value
21	Bone meal ...	8·64	29·16	2·99	3·86	23·36	106
22	Ditto ...	9·57	26·18	1·39	3·70	24·39	107
29	Fish (Milled) ...	2·11	44·58	38·47	4·24	4·65	57½
30	Ditto ...	2·21	42·16	40·14	4·40	5·05	60

G. Potash Fertilizers.

37. Even those Indian Agriculturists who have been using commercial fertilizers to a comparatively large extent have bought comparatively little potash. Crude and refined saltpetre and ashes are the forms in which this constituent of plant food has been most readily bought up to date. But recently the German potash salts have been put on the market. Numbers 15, 16 and 17 in the table below represent the three most valuable of these salts. Of course the sulphate of potash is the most valuable, not only because it contains the largest percentage of potash, but also because in that form the potash it contains is probably most valuable. When applying potash manures to soils lime should also be used. The reason is that the lime is required to preserve the mechanical condition of the soil

which the potash fertilizer has a tendency to destroy. It is also needed to make the potash which combines with the soil available for plant food. In India where the soils are, as a rule, poor in lime, this precaution to use lime on the fields which have received a dressing of potash fertilizers is of more importance than in some other parts of the world. Like nitrates potash fertilizers should not be applied just before the monsoon but for a totally different reason. The nitrates would be washed out of the soil. The potash would tend to puddle the soil.

Table XII.—Composition of Potash Fertilizers.

No.	Substance.	Moisture.	Potash.	Nitrogen	Approximate relative value.
15	Kainite	2·58	12·36	.....	34½
16	Muriate of Potash ..	2·92	51·04	.....	141½
17	Sulphate of Potash ...	·90	52·05	.....	145½
19	Crude Saltpetre ...	9·33	19·57	3·43	91
13	Ditto do ...	3·02	17·43	3·79	88½

38. *Guaranteed Analyses.*—In addition to above fertilizers several mixed fertilizers were analysed to enable the dealer to give a guarantee with these fertilizers as to their actual composition. This matter of guaranteeing the fertilizer offered for sale has made considerable progress during the year. The matter was again brought up for discussion at the United Planters' Association and that body passed a strong resolution in its favour. Two of the dealers are starting a Chemical Laboratory at their works. A partner of one of the firms has already taken a course of instruction at the Laboratory here, and has practically finished building his own Laboratory. The other firm has ordered the necessary apparatus, and one of its partners will take a course of instruction when the apparatus arrives. Most of the

other firms are guaranteeing their fertilizers notwithstanding that they have found some difficulty in getting analyses of fertilizers made just when they want them.

H. Water.

39. Considerable work has been done in investigating the waters of a tributary of the Arkavati river with a view of finding a way to purify this water sufficiently for domestic purposes. A brief report has been made on the subject already. To give the conclusions arrived at wider publicity, a few of the analyses are given below :—

Table XIII.

No.	Description.	Free Ammonia parts per million.	Albumenoid Ammonia parts per million.
68	Waste Wash from Distillery ...	Nil.	9·04
70	Water from river a quarter of a mile below inflow of Waste Wash.	Nil.	3·26
75	Water from river about 3½ miles from inflow of Waste Wash.	·28	1·62
76	Water from a shallow pit about 8 feet from water's edge close to the point where sample No. 75 was taken.	1·38	·72
71	Water from river about 5½ miles from inflow of Waste Wash.	·25	2·28
77	Water from a well dug about 100 feet from edge of river at a point near that where sample No. 71 was taken.	·160	·105

40. By comparing sample No. 76 with sample No. 75 we will note the change made by a filtration through a loose sand partly impregnated with the contaminating substance.

41. The "Waste Wash" has a tendency to form crusts and flocculent substances on exposure to the air or even on standing. These are of course removed by the sand and the "albumenoid" ammonia is, therefore reduced, because the organic impurities containing this "albumenoid" ammonia is partially filtered out. The free ammonia which is produced by the decomposition of vegetable or animal matter is present in much larger quantities in the pit water. This is no doubt due to the fact that the flocculent matter which was filtered out by sand gradually decomposes and the products of this decomposition are washed out by the water passing through the sand on its way to the pit. When comparing sample No. 77, taken from the well, with sample No. 71, taken from the river just opposite, the effect of filtering through a much larger stratum of undisturbed soil will be noticed. This filtration is decidedly beneficial. Both the "free" and "albumenoid" ammonia are very greatly reduced, which indicates that the water has been materially improved in quality. The conclusion therefore is to discourage the use of the river water directly and to encourage the digging of wells not far from the river bank. These wells would probably have as constant a supply of water as the river itself.

42. From a chemical standpoint this series of analyses is very interesting. The waste wash contained no free ammonia, and though it appeared neutral to litmus paper the very slight quantity of free sulphuric acid which it contained fixed the 0·34 parts per million of free ammonia contained in the river water above the inflow of this "Waste Wash." The organic matter in the latter was so resistant to an alkaline permanganate solution that notwithstanding that three times the ordinary quantity of permanganate were added, the original 500 c. c. of water taken for analysis were nearly all distilled off, again diluted and another 250 c. c. of water distilled over, even then the distillate was far from being free from ammonia. The figure given in the above table was determined by the Kjeldahl method. With the alkaline permanganate method only 7·5 parts per million instead of 9·04 parts per million were obtained,

In sample No. 70, the albumenoid ammonia was determined by both the Kjeldahl and the alkaline permanganate methods. Both gave practically the same results though the permanganate method worked very slowly. All the other samples were analysed in the ordinary way. The water from which sample No. 71 was taken was very much darker in colour than sample No. 75, taken two miles nearer the inflow of the waste wash. It also contained much more albumenoid ammonia. It is difficult to explain this phenomenon.

43. *Well Water.*—A sample of well water used for irrigating a lucerne garden was analysed, because the owner of the garden had noticed that the Bangalore pipe water when used for irrigation appeared to exert an injurious effect on the lucerne when compared with the water of this well. It is natural to expect that the apparent injurious results of the pipe water could be accounted for by the well water containing some plant food which is absent in the pipe water. But as the pipe water is used for irrigating the experimental plot in the Laboratory compound, it was considered necessary to make sure that the apparent injurious effect was really due to the well water containing manurial constituents dissolved in it. The analysis of the well water showed that it contained nitrates and ammonia equivalent to 9·52 parts per million, a quantity which would give 1·7 lbs. of nitrogen per acre for every inch of water supplied, or 85 lbs. of nitrogen for every 50 inch of irrigation water. This is equivalent to a dressing of over 54 tons per acre with cattle manure having a composition similar to sample No. 35 referred to on page 17 of this report.

44. *Grass Oil.*—Three samples of grass oil were examined, one from Sulekere where the oil is distilled on a commercial scale and two samples from the Nilgiris where the industry is not yet established. The three samples were subjected to fractional distillation and of each distillate the refractive index and dispersion were determined with an Abbe Refractometer. The results are given below.

Table XIV.—Grass Oil.

No.	Locality.	Boiling point of distillate degrees, Centigrade.		Percentage distilled over.	Refractive Index.	Dispersion	Specific gravity at 27½ Centigrade.
		From.	To.				
69	Sulekere ..	...	...	...	...		·8755
		213	223	35·4	1·4700	·0135	
		223	233	51·4	1·4700	·0135	
		233	250	4·2	1·4702	·0135	
		250	∞	9·0	1·4798	·0117	
70	Nilgiris ...	...	...	...	...	...	·9577
		175	190	23·3	1·4730	·0115	
		190	230	5·2	1·4804	·0126	
		230	240	4·9	1·4768	·0116	
		240	260	17·8	1·4884	·0118	
		260	270	25·0	1·5078	·0138	
		270	∞	20·0	1·5220	·0156	
71	Ditto ..	...	...	...	...	...	·9410
		165	190	7·6	1·4733	·0116	
		190	230	25·3	1·4774	·0116	
		230	240	5·3	1·4840	·0117	
		240	260	23·0	1·4960	·0120	
		260	270	20·0	1·5084	·0138	
		270	∞	12·1	1·5182	·0140	

45. The wide range of boiling point indicates that none of the oils are pure. But No. 69 is undoubtedly very much purer than either of the other two, for in it over 80 per cent of the oil came over in a range of 20 degrees of temperature. Both the refractive index and the dispersion are identical for about 90 per cent of this oil. Neither of the other two samples contains any large quantity of the oil which composes the bulk of sample No. 69, and both are composed of a mixture of at least two different oils, and the oils which are found in No. 70 are not quite the same as the oils found in mixture No. 71. The odour of the three samples was also different, though both Nos. 70 and 71 had a decided lemon smell which was absent in No. 69. The rotation of the oils could not be determined with a Schmidt and Haensch half shadow instrument. The specific gravities also vary very much.

46. *Paper.*—Out of 63 samples of paper sent in for examination, 21 were examined microscopically for wood pulp. These papers were of very varying quality and intended for various uses:—(Writing papers, wrapping papers, printing papers and blotting papers). Nearly all contained some form of straw or grass, a few contained cotton as well; one was made principally from cotton and only one contained wood pulp.

47. *Entomology.*—During the year inquiries about insect pests have been even more numerous than in the previous years. The Castor pest reported last year on page 17 of the Third Annual Report re-appeared in Davangere, as was feared would be the case. A beetle very similar to Oryctes rhynoceros reported last year as one of the date palm pests is reported to have done considerable damage to cocoanut palms and even to sugar cane. There has been no diminution in the attack of the Green bug, a Lecanium in the coffee districts, but on the contrary the pest has spread. The paddy pest which occurred in T. Narsipur Taluk last year has not been reported this year and has certainly not occurred to the same extent as last year. But I fear it has not been entirely absent. The Mango pest (*Euroctis lunata*) has again wrought its destruction in Maddagiri Taluk. The very primitive arrangements made for applying Paris Green were not thorough enough to check the disease. A proper spraying apparatus has, however, been imported from the Spray Motor Co. of London, Canada and it is hoped that next year it will be possible to properly test and demonstrate the efficiency of Paris Green in fighting this and similar pests.

48. In addition to the above insects which were reported on at some length last year, samples of various insects attacking garden crops were received; among these were cut worms attacking cabbages, girdlers destroying grape vines and various plant lice. The latter also attacked the gingelly crop. Three pests attacking ragi and another attacking mangoes were also noted. Locusts were sent from several places in and near the State. Two of the worst pests of coffee were sent from the Nilgiri Hills.

Weevil and another beetle totally destroyed grain stored for seed in various parts of the State.

49. None of these insect pests could be thoroughly investigated and none of the remedies used in Europe or America against similar pests could be tested before being recommended as worthy of a trial to the persons interested in the affected crops. As a result very little was actually done in Mysore to fight these pests during the year under review, notwithstanding that a by no means insignificant amount of time was devoted to this subject.

50. *Machinery.*—In addition to the Spraying apparatus referred to in the entomological part of this report, the only machine imported was a small Engelberg rice-huller sent by the manufacturers for exhibition purposes. A two-horse-power engine is required to work the machine. 107 lbs. of Sanna bhatta paddy were thoroughly cleaned in 20 minutes and gave 70 lbs. of clean rice. Or by measure 61 seers of paddy gave 30½ seers of rice. This is a small grained "white" paddy. With a red paddy (Doddy variety was used) the quantity cleaned is smaller; but the advantage of the machine is much more apparent as the rice turned out by the machine is perfectly white, while the hand cleaned paddy is a dirty red. So far as can be judged from 5 or 6 trial runs of a few hours each, the machine works very satisfactorily indeed. One or two of the samples of paddy used for these experiments were very badly cracked. Of course as the paddy was cracked before going into the machine the cleaned rice was also cracked. The fault lay not in the machine but in the paddy. The causes producing cracked paddy will have to be investigated as there is considerable wastage with cracked paddy, the percentage of paddy turned out as cleaned rice being much less.

51. The principle on which this rice-huller works is very similar to that used when pounding it by hand. It is friction of one paddy grain on another. This friction produces heat, and the greater this friction the greater the heat produced. In these rice-hullers it is therefore much greater than when the paddy is cleaned by hand. In these

tests the paddy was heated up to between 70 and 80 degrees, Centigrade, a temperature below the boiling point of water. This heating is similar to that applied when boiling and is quite harmless. It is an external source of heat and must not be mixed up with the heat produced by fermentation.

A. LEHMANN,
Agricultural Chemist.

DEPARTMENT OF AGRICULTURE, MYSORE STATE.

FIFTH ANNUAL REPORT

OF THE

AGRICULTURAL CHEMIST

FOR THE YEAR 1903-1904.

Kanarese and English Reports and Bulletins of the Department of Agriculture will be sent free to Planters, or Raiyats, who apply for them, so long as the supply lasts.

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1905.

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FIFTH ANNUAL REPORT OF THE AGRICULTURAL CHEMIST FOR THE YEAR 1903-04.

PART II.

16. Part I (paras 1 to 15 of this report) which bears on the general working of the Department is not intended for distribution. Part II contains results of plot experiments and gives the composition of different samples of coffee, fertilizers, "famine foods," sugar-cane, jaggory and miscellaneous analyses.

17. The experiments in the Laboratory compound were continued this year although, as reported last year, the ground is not suitable for this work.

SUGAR-CANE.

18. Preliminary experiments were made with sugar-cane with a view—

(1) to compare sub-soil irrigation with surface irrigation,
(2) to try the effect of deep cultivation,
(3) to compare some varieties.

The sugar-cane was manured throughout with the same quantity of fertilizer, *viz.*, 25 lbs. of white castor meal, 5 lbs. of bone meal and 2 lbs. of muriate of potash per row of 97 feet in length. The soil was ploughed about 6 inches deep (except where otherwise stated) with a mould-board plough (Canadian) and was cultivated twice with a Planet Junior horse hoe to give a loose friable surface. The cane was planted in furrows about five inches deep and three feet apart on February 25th and 26th. One continuous row of whole stalks was placed in each furrow. Where necessary the canes were cut to straighten them, after which they were covered with two to three inches of fine soil. As both the soil and season

were dry, enough water was let into the trenches to moisten the soil. The canes sprouted fairly evenly, but here and there were gaps of three or four feet and in two or three places larger gaps. Unless otherwise stated, the cane planted was the ordinary striped cane locally known as Pattapatti. The cane was brought from Kunigal where three years before the Department analysed a number of samples of cane juice and the jaggories obtained from them as reported on page 10 of the Second Annual Report.

19. *Sub-soil Irrigation.*—Sugar-cane is generally supposed to require a loose friable surface soil to give best returns. When frequently irrigated on the surface it is difficult, if not impossible, to keep the surface soil in this loose friable condition. An attempt was made to supply the necessay water by allowing this to stand in open drains between the plots. It was hoped that by lateral capillary action sufficient moisture might be carried to the rows of cane on the adjoining plots. To test the extent of this lateral capillary movement the plots were made varying from 12 to 18 feet wide. The surface of the sub-soil water was at such a depth that it could not in any way assist the lateral distribution of the water in the drains. In the earlier parts of the experiment these drains were filled with water whenever the other part of the field was irrigated. But as the rows in the centre of all the plots began to wilt soon after, surface irrigation was applied to these "sub-soil irrigated" plots as well to keep the plants in good condition until the water from the drains had had time to "soak in". When no signs of this soaking in could be noticed after four weeks, the drains were kept full of water for two weeks, and when it was found that even then only the rows of cane next to the drains could do without surface irrigation, sub-soil irrigation was abandoned. The result of this experiment appears to indicate that in a soil naturally well drained very little lateral capillary action takes place. The fact that under a heap of leaves or other mulch the soil may be quite moist and immediately beyond this heap dry to a depth of several feet, indicates the same thing. The fertilizer experiments with grasses at Rothamsted appear to point in

the same direction. Generally sugar-cane is grown on lands where the surface of the sub-soil water is very much nearer the surface of the soil than is the case in the Laboratory compound; and the fact that sub-soil irrigation did not answer for sugar-cane in the Laboratory compound does not prove that it will fail on ordinary sugar-cane lands. Discontinuing the sub-soil irrigation experiments gave plots I (b), (c), (d), (g) & (h) and plots II (a), (b) & (e) practically the same treatment. The differences in yield of canes given for these plots in the following Table No. I are partially due to an attack of white-ants and partially to differences in soil:—

TABLE No. I.

Yield of sugar-cane per acre and per cent of extraction.

Plot No.	Area Acres	Weight of canes in lbs.	Weight of canes per acre in lbs.	Weight of juice got from 100 lbs. of cane
Plot I (a) ...	$\frac{1}{75}$	371	27,825	66·0
Do (b) ...	$\frac{1}{50}$	1,178	58,900	69·1
Do (c) ...	$\frac{2}{75}$	1,129	42,337	70·9
Do (d) ...	$\frac{1}{30}$	1,818	54,540	68·5
Do (e) ..	$\frac{1}{75}$	743	55,725	70·0
Do (f) ...	$\frac{1}{50}$	963	48,150	66·0
Do (g) ...	$\frac{1}{100}$	491	49,100	70·1
Do (h) ...	Do	564	56,400	62·1
Plot II (a) ...	Do	657	65,700	67·1
Do (b) ...	Do	606	60,600	71·9
Do (c) ...	Do	691	69,100	67·3
Do (d) ...	Do	636	63,600	70·0
Do (e) ...	Do	527	52,700	69·4
Do (f) ...	Do	603	60,300	71·3
Do (g) ...	Do	575	57,500	70·8
Plot III (a) ...	$\frac{1}{75}$	470	35,250	69·1
Do (b) ...	Do	258	19,350	67·1
Do (c) ..	$\frac{1}{150}$	122	18,300	70·5
Do (d) ...	Do	58	8,700	58·6
Do (e) ...	$\frac{1}{300}$	48	14,400	58·3
Do (f) ...	$\frac{1}{75}$	68	5,100	64·7
Do (g) ...	$\frac{1}{300}$	37	11,100	64·9
Do (h) ...	Do	48	14,400	68·8
Do (i) ...	Do	35	10,500	65·7

20. *Cultivation and Variety Experiments.*—Plots I (e) and II (c), (d), (f) and (g) were dug two feet deep before planting. On some the manure was applied before digging so that it was mixed with the two feet of soil. On other plots it was applied after digging so that it remained near the surface. Plot III was planted with 10 varieties of cane. But in view of the great differences of yield obtained from plots treated alike any difference in crop obtained from these plots cannot be interpreted as showing any advantage or disadvantage due to treatment or variety. This subject is more fully dealt with under experiments with ragi on para 33, page 14 of this report.

21. *Sprouting of Cane.*—Cane often sprouts when lodged. But if it sprouts when standing erect, it is generally taken as an indication that it is nearly or quite ready to cut. The cane in the Laboratory compound began sprouting here and there very early. Some sprouts which were allowed to grow were practically the same size as the parent stalk when cut in February. In December a comparatively large number of canes sprouted, that is, the buds on the stalks began to grow. The following table shows the composition of sprouted and unsprouted cane, also a sample of nearly ripe cane :—

TABLE No. II.

Comparing composition of sprouted and normal cane.

Date	Substance	Glucose	Sucrose
Dec. 24 ...	Sprouted cane ...	1·85	13·9
Dec. 24 ..	Normal cane ..	2·55	11 5
Jan. 6 ..	Sprouted cane ...	1·51	15·1
Jan. 6 ...	Normal cane ...	2·89	11·5
March 27 ...	Normal cane nearly ripe	·8	20·1

These are all the same variety of cane grown under the same conditions. None of them are ripe, for even in the sample cut on March 27th the percentage of glucose is too high for this variety of cane in this climate. Here the glucose contents of really good cane should drop below half a per cent when ripe. But it will be seen that the sprouted cane has much less glucose and more sucrose (cane sugar) than samples of normal cane cut on the same day. It is therefore the more mature stalks which showed the greater tendency to sprout.

22. *Ripening of Cane.*—The following Table No. III gives the composition of cane at various periods of growth:—

TABLE No. III.

Composition of cane on various dates.

Date				Glucose	Sucrose
December	24	...	...	2·55	11·5
January	6	..	...	2·89	11·5
Do	20	...	.	1·66	15·3
February	4	...	...	1·8	16·5
Do	15	..	...	1·6	16·2
March	27	...	...	·8	20·1

23. All the canes in the field are not of the same age, and it is impossible to get absolutely representative samples when only cutting a few canes as is done for these tests. In the above table all the samples are of the same variety, *viz.*, Pattapatti. Most of the other varieties appear to mature earlier, for of the eight varieties cut on March 29th, 30th and 31st, five had half a per cent of glucose or less, and over 20 per cent of sucrose

(cane sugar). Glucose, the sugar which causes the jaggory to run in the monsoon and which is largely lost in the molasses when the jaggory is refined and converted into sugar, is a compound out of which sucrose or cane sugar is formed in the growing plant later on. This latter forms the valuable part of sugar-cane, while the glucose detracts from the value of the cane. Therefore the riper the cane and the more sucrose and less glucose it contains the more valuable it becomes. From December 24th to March 27th the glucose dropped to about one-third and the sucrose nearly doubled. From a sugar-maker's standpoint the cane had therefore more than doubled in value, weight for weight, in these three months. But in addition to this the cane most likely continued to grow and the increased weight made a further increase in value. As stated before, the cane was not quite ripe on March 27th. But for Departmental reasons harvesting had to begin before the 15th of March. The cane was therefore not of as good quality as it would have been about a month later. In Table No. IV given below are recorded the average composition of the juice from each plot and the average composition of the jaggory boiled from it :—

TABLE No. IV.

Composition of Juice and Jaggory from sugar-cane plots.

No.	Substance	Sucrose	Glucose	Total solids
212	Juice from I (a) ...	18·8	1·07	20·50
213	Jaggory from I (a) ...	84·5	4·00	
214, 216, 218	Juice from I (b) ...	18·1	1·59	20·19
215, 217, 219	Jaggory from I (b) ...	82·3	6·00	
220, 222	Juice from I (c) ...	17·0	1·80	19·65
221, 223	Jaggory from I (c) ...	82·0	8·10	

TABLE No. IV—contd.

No.	Substance	Sucrose	Glucose	Total solids
224, 226, 228	Juice from I (d) ...	17·4	1·60	19·20
225, 227, 229	Jaggory from I (d) ...	81·4	7·30	
230	Juice from I (e) ...	18·2	1·30	19·85
231	Jaggory from I (e) ...	82·0	6·20	
232, 234	Juice from I (f) ...	16·5	1·75	19·00
233, 235	Jaggory from I (f) ..	79·7	7·80	
236	Juice from I (g) ...	18·0	1·70	20·00
237	Jaggory from I (g) ..	84·6	6·00	
238	Juice from I (h) ..	17·3	1·90	19·48
239	Jaggory from I (h) ...	81·6	7·90	
240	Juice from II (a) ...	17·6	1·90	19·70
241	Jaggory from II (a) ...	77·3	10·60	
242	Juice from II (b) ..	17·0	1·70	19·30
243	Jaggory from II (b) ...	78·7	10·80	
244	Juice from II (c) ...	18·1	1·40	19·90
245	Jaggory from II (c) ...	80·4	8·00	
246	Juice from II (d) ...	17·3	1·70	19·60
247	Jaggory from II (d) ...	79·7	8·30	
248	Juice from II (e) ..	16·6	1·40	20·87
249	Jaggory from II (e) ...	82·0	6·60	
252	Juice from II (f) ..	20·1	·80	21·76
253	Jaggory from II (f) ...	83·5	6·90	
250	Juice from II (g) ..	19·3	1·10	20·64
251	Jaggory from II (g) ...	85·2	5·40	
256	Juice from III (a) ..	19·5	1·08	21·44
257	Do III (c) ...	21·2	·40	22·16
	Average of III (a & c) ...	20·3	·74	21·80
258	Jaggory from III (a & c) ...	84·7	5·40	
254	Juice from III (b) ...	19·8	·74	21·16
255	Jaggory from III (b) ...	86·5	4·70	
259	Juice from III (d) ...	20·2	·40	21·16
260	Do III (e) ..	20·6	·30	21·16
261	Do III (f) ..	20·1	·50	20·80
262	Do III (g) ...	20·3	·50	20·90
263	Do III (h) ...	19·5	1·70	21·60
264	Do III (I) ...	20·8	1·00	22·57
	Average of III (d to I) ...	20·2	·73	21·36
265	Jaggory from III (d to I) ...	86·3	4·60	

24. The cane was milled by an ordinary vertical three-roller iron mill which is largely used throughout the State. The rollers are of equal size, 7 inches in diameter, 9 inches long. The juice was collected from the mill in galvanized iron pails, but by mistake stored in earthenware pots when the pan was not ready to receive the juice as milled. It was limed *to neutrality* as tested by litmus paper before boiling. The skum rising to the surface just before the juice comes to a boil was skimmed off and strained through a coarse cotton cloth. The vessel in which the jaggory was boiled was an ordinary shallow iron pan as generally used by the raiyats. After this pan was thoroughly clean, the jaggory produced was of a *bright yellow colour*. In this case the *liming to neutrality had no injurious effect on the colour*. But the jaggory was very firm and none of the samples showed the slightest sign of running or of "sweating" during the monsoon.

25. In jaggories Nos. 213 to 239 no loss of sugar (inversion) occurred during boiling. But in all the other jaggories which were boiled after that, a considerable loss of sugar occurred through inversion. Why there was this difference is hard to explain unless it was caused by fermentation while standing in the earthenware pots. These, although washed every time after they were used, must have absorbed more or less juice into their pores which could not be removed by washing. This no doubt fermented after a time and acted as a source of contamination for the juice stored in these pots later on. This may possibly account for the loss of sugar in the later boilings.

26. When boiling jaggory the greatest care should be taken—

(1) to lime the juice to neutrality as indicated by litmus paper,

(2) to use no earthenware pots,

(3) to carefully wash the mill and all pots and vessels at least once a day *before* stopping work,

(4) to boil the juice as soon after it is milled as possible.

(5) to see that the rollers of the mill are set as close together as possible.

27. *Extraction.*—As will be seen by comparing the figures in the last column of Table No. I (page 3 of this report) giving the weight of juice got from 100 lbs. of cane, there is a considerable difference in these figures. The difference in extraction between plot II (f) and I (h) amounts to about 50 maunds (of 28 lbs.) of jaggory per acre and this would be equivalent to a loss of Rs. 50. But it is probable that the loss from faulty milling is much greater than this. The question will be studied more fully as soon as time and opportunity permit.

28. *Centrifugals.*—As pointed out in the first annual report, the aim of those interested in sugar-cane growing

will have to be directed to the production of raw sugars instead of jaggory. Notwithstanding that the present methods of jaggory-making are capable of considerable improvement, the sugar industry must gradually decline if jaggory is made instead of raw sugars. In order to replace, or even to compete with the sugar at present imported in such large quantities into India, we must produce a sugar which can be easily refined. For refining purposes it is infinitely better to produce raw sugars than jaggory. And unless this is done, the sugar industry must decline with the gradually declining consumption of jaggory as such. This season it was only possible to produce one sample of raw centrifugalled sugar at the Laboratory. It contained 94·1 per cent of sucrose and 2·45 per cent of glucose. It is hoped that next season will give opportunities of doing more in this line of work.

Ragi.

29. Preliminary experiments with ragi were conducted in the Laboratory compound on plots of $\frac{1}{200}$ of an acre to obtain some hints as to the direction in which experiments with this crop would likely be successful.* These preliminary experiments were divided into three parts : (*a*) varieties, (*b*) cultivation and (*c*) manuring.

30. (*a*) *Varieties.*—Eleven varieties were collected by two of the Agricultural Assistants of this Department in the Bangalore District. These were sown on plots liberally manured with bone meal, poonac and kainit. All the plots were of course manured and cultivated alike. No duplicate plots were used as the experiments were chiefly (1)to ascertain if any characteristic difference existed in the form of growth of the varieties, (2) if there was any marked difference in time of ripening, and (3) to get the different varieties as true to name a possible, for as might be expected they were all mixed more or less.

* All the ragi plots were sown on the 4th August 1903 and harvested on 13th, 14th and 15th December 1903.

The following table gives the yields per plot in straw and chaff together and grain :—

TABLE No. V.

Ragi Varieties.

Range and plot	Variety		Particulars of cultivation	Particulars of manure	Yield of stalks in lbs.	Yield of grain		Yield per acre of grain in lbs.
						lbs.	oz.	
Range A. Plot 16.	Majiige	Ragi ...	Canadian plough	18¾ lbs of castor. 3¾ lbs bone meal. 1½ lbs muriate of potash.	51	4	10	925
Do do 17...	Konanakombina	do ..	Do .	Do ...	42½	5	2½	1,031
Do do 18...	Jannmuddina	do ...	Do ...	Do ...	52	9	5¼	1,865
Do do 19..	Balepatte	do ...	Do ...	Do ..	42½	7	2	1,425
Do do 20...	Gidda	do ...	Do .	Do ...	45	6	5½	1,268
Do do 21...	Sannakari	do ...	Do ...	Do ...	46	7	8½	1,506
Range B. Plot 15.	Hullubile	do ...	Do .	Do ...	20	6	13	1,362
Do do 17...	Hasarukambi	do ..	Do ...	Do ...	27	6	14½	1,381
Do do 18..	Dodda	do ...	Do ...	Do ...	32	6	2	1,225
Do do 19..	Gundutanekari	do ...	Do ...	Do ..	43	6	3½	1,243
Do do 20...	Madayanagiri	do ...	D ..	Do ...	29	6	1½	1,218

31. As will be noticed in the following Table No. VI, the results of duplicate plots vary very much especially in the unmanured plots and those treated with cattle manure. This indicates, as pointed out later on, that the soil on which these experiments were made is very uneven and that even comparatively large differences such as those found in plot No. 16 and plot No. 18 may be largely due to differences in the soil. At any rate no trustworthy conclusions can be drawn, for at least a few years to come, as to the variety of grain which is likely to give the best results in response to such liberal treatment as these plots received. Any comment as to differences in growth and length of time required for maturing will also be reserved for the future.

32. (*b*) *Method of Cultivation.*—In these experiments were compared :—(1) Ploughing with an ordinary Mysore plough. In this the surface soil is simply loosened and the soil is not turned over. (2) Ploughing with a light one-horse Canadian plough. This is a light, small form of the ordinary European or American plough with a detachable mouldboard, land-side, sole, plough points, etc., and turns the soil over. With this was turned a furrow about six inches deep. (3) Loosening the soil by hand to a depth of about 18 inches.

TABLE No. VI.

Ragi, Manurial and Cultivation Experiments.

Range and Plot	Particulars of cultivation	Particulars of Manure	Yield of straw and chaff in lbs. per plot	Yield of grain lbs.	Yield of grain oz.	Yield per acre of grain in lbs.
Range B Plot 2.	Mysore plough.	No manure ...	I 2½	..	13½	168
Do 9 ..	Do	Do ...	II 4	1	9½	318
Do 3 ...	Do	2½ Cwts. of farm yard manure.	I 6½	2	2½	431
Do 10 ...	Do	Do ...	II 9½	3	4½	656
Do 11 ...	Canadian plough	No manure ...	I 4½	3	8	700
Do 5 ...	Do	2½ Cwts. of farm yard manure.	I 5½	1	14½	381
Do 12 ..	Do	Do ...	II 7	3	11½	743
Do 6 ...	Do	18¾ lbs. of white castor meal. 3¾ lbs. bone meal ... 1½ lbs. muriate of potash	I 28½	7	5¾	1,472
Do 13 ...	Do	Do ..	II 26½	10	5	2,062
Do 7 ...	Do	Double the above dose ...	I 39	7	...	1,400
Do 14 ...	Do	Do ...	II 33½	9	8	1,900
Do 8 ...	Soil dug 2 ft. deep.	18¾ lbs. of white castor meal ... 3¾ lbs. of bone meal ... 1½ lbs. of muriate of potash ...	21½	6	13¾	1,371
Do 15 ...	Do	Double the above dose ...	20	6	13	1,362

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Do 12 ..	Do	Do ...	II 7	3	11½	743
Do 6 ...	Do	18¾ lbs. of white castor meal. 3¾ lbs. bone meal ... 1½ lbs. muriate of potash	I 28½	7	5¾	1,472
Do 13 ...	Do	Do ..	II 26½	10	5	2,062
Do 7 ...	Do	Double the above dose ...	I 39	7	...	1,400
Do 14 ...	Do	Do ...	II 33½	9	8	1,900
Do 8 ...	Soil dug 2 ft. deep.	18¾ lbs. of white castor meal ... 3¾ lbs. of bone meal ... 1½ lbs. of muriate of potash ...	21½	6	13¾	1,371
Do 15 ...	Do	Double the above dose ...	20	6	13	1,362

33. Here a number of duplicate plots were introduced to test the uniformity of the soil and show what confidence might be placed in the results of the experiments. These duplicate plots are bracketted in Table No. VI above. Plots No. 2 and No. 9 are the first duplicates given. The two duplicate plots were treated exactly alike in each case and should have given practically the same results if the soil and other conditions had been such as are required on an experimental field. The fact that plot No. 9 gives nearly double the yield obtained from plot No. 2, indicates that the field notwithstanding that it looks quite uniform to the eye is unsuited for experimental work. For, if these two plots had been used for comparative experiments, any difference in crop would be attributed to the difference in the experiment, while in reality a very large proportion would be due to difference in soil. If, for example, we had applied a fertilizer to plot No. 2 which had increased the yield of grain, say, 100 lbs. per acre, the apparent result would have been that the fertilizer had, instead of increasing the yield, actually reduced the yield by 50 lbs. per acre, *this may illustrate how carefully field experiments must be conducted to avoid misleading conclusions.* If only one set of duplicates had given widely different results and the others all concordant results, we might select a portion of the field for experiments. But as five out of the six duplicates have given widely different results, the results of all the experiments conducted in this field must be regarded with suspicion for some years to come. But it is possible that with continued cultivation the soil may give more even crops in the future ; for, until quite recently this field had been "waste lands."

34. Considering the above we cannot even rely on the very great difference in the crop obtained from plot No. 2 and plot No. 11, being really due even in part to a better system of cultivation notwithstanding that the crop on plot No. 11 is practically four times as large as on plot No. 2 and more than double that on plot No. 9 which are all unmanured. For, if we compare the averages of plots

Nos. 3 and 10 with those of plots Nos. 5 and 12, we find only a comparatively slight increase in favour of the plots ploughed with the Canadian implement. Still the tendency is in that direction.

35. The deep digging has, judging by the results under review, had no apparent advantage. But judging by the present appearance of the second year's crop there will be a decided apparent advantage in its favour next year. And of course the longer these experiments are continued the more valuable the results will become.

36. (*c*) *Manure Experiments.*—The increase in crop produced by liberal manuring with commercial fertilizers is so great that in comparison with it even the great differences in the soil became comparatively small. Comparing the average results of plots Nos. 6 and 13 with plots Nos. 7 and 14 and the yield of plot No. 8 with plot No. 15, there is apparently a slight decrease produced by applying the double dose of fertilizer, and very possibly the single dose is already more than is required to give best returns, considering the cost of the manure applied. The amount of cattle manure applied does not give as much plant food as is contained in the single dose of commercial fertilizer. It was wet manure and contained :—

Moisture	...	72·09	Per cent.
Loss on ignition	...	7·51	„
Insoluble residue	...	11·39	„
Nitrogen	...	·18	„
Potash	...	·24	„
Lime	...	·31	„
Phosphoric acid	...	·09	„

37. But the increase in grain on the plots to which cattle manure has been applied, though far short of that produced by the commercial fertilizers, would be apparent in the table if plot No. 11 could be eliminated from it, and is clearly indicated in an increased yield of straw. The average of the plots manured with commercial fertilizers is more than four times the crop obtained on the average from the unmanured plots.

SWEET POTATOES AND GROUND-NUTS.

38. *Experiments with varieties of sweet potato* (*Ipomœa Batatas*) and miscellaneous experiments:—

TABLE No. VII.

Variety	Yield per acre in lbs.	Remarks
Virginia ...	13,050	The plots were each $\frac{1}{25}$ of an acre in extent, were plouged with a Canadian plough and manured with 150 lbs. of castor, 30 lbs. of bone and 12 lbs. of muriate of potash, for each plot.
Nansemond ...	14,875	
New Jersey ...	14,175	

Of the three varieties grown, the Virginia produced the largest tubers, some weighing 1 lb. & 9 oz. and many weighing 1 lb. & 4 oz. The Nansemond produced tubers much smaller than those produced by the other two varieties. In order to avoid the frequent turning over of the creepers (which is necessary to prevent the development of adventitious roots to the detriment of tubers) a few rows of the 1st plot were provided with a trellis over which the creeper was trailed. The general yield of this portion was no better although some of the largest tubers were found there.

39. Three varieties of ground-nuts were grown in plots of $\frac{1}{50}$ of an acre with a view to compare the yield under similar treatment in regard to manure and cultivation. It will be seen from the results given below that the Virginia variety gave the highest and the Pondicherry the lowest. But owing to the unevenness of the soil these figures do not necessarily indicate the relative value of these varieties. The pods of the Virginia and the Japanese varieties were, moreover, much larger than any produced by the local varieties, the size of the Virginia being remarkable. Small quantities of these pods were distributed free, and some sold for seed purposes to applicants for the same.

TABLE No. VIII.

40. *Yield of Ground-nut* (*Arachis Hypogæa*).—

Variety	Yield per acre in lbs.
Japanese	8,950
Virginia	10,100
Pondicherry	6,925

41. The three varieties of ground-nuts and the three varieties of sweet potatoes were kindly sent by J. W. Mollison, Esq., M.R.A.C., Inspector General of Agriculture to the Government of India.

Quality of Coffee.

42. For the continuation of the work on quality of coffee reported on in the Fourth Annual Report, page 9, the United Planters' Association of Southern India sent 51 samples of coffee and a list of prices these coffees realised on the London market. Unfortunately, it is not stated in how far the various lots of coffee represented by these samples were sold on the liquoring test, nor did an expert report as to colour and general appearance accompany the samples. The chemical analyses of these samples is only partially finished. But as the subject of "Quality of Coffee" is one of special interest, the specific gravities of these 51 samples and their market price are given below. The samples from each district are grouped together as it was found that by including all the samples in one table different varieties or strains of coffee would be grouped together, the specific gravities of which (with our present knowledge of the subject) could not be compared with each other. A striking example of this is still to be found in the five samples of Costarican coffee enumerated in Table No. XV. Of these five samples No. 97 and No. 116 are one variety and the remaining samples a distinctly different variety. The specific gravities were determined by the Westphal balance in

alcohol of specific gravity varying between ·821 and ·829. This worked much more satisfactorily than the method adopted in the year 1902-03. But even by substituting the water by alcohol the method is not yet as reliable as it should be; for duplicate tests did not always give concordant results, and four or five determinations had occasionally to be made of the same sample.

TABLE No. IX.

Mysore Coffee.

No.	Price realised	Specific Gravity	Comparative rank in		Remarks
			Sp. Gr.	Price	
127	114	1·281	1	1	
128	112	1·270	2	2	Much better color than No. 1.
105	95	1·259	6	3	Very fine looking sample, flat beans, straight seams.
101	92	1·263	3	4	
102	88	1·262	4	5	
100	74	1·262	5	6	
107	62	1·237	11	7	
83	60	1·241	10	8	
129	57	1·251	9	9	
84	55	1·254	8	10	Very poor, faded color.
130	50	1·257	7	11	Very poor, bleached sample.
106	49	1·233	13	12	
85	47	1·234	12	13	

43. Sample No. 128 has, so far as can be judged now, a very much better color than No. 129, still it brought a lower price in the market and has a decidedly lower specific gravity. The coffee from the estate on which these samples were grown is, I believe, generally sold on the "liquoring test." Sample No. 105 is a very fine-looking even sample, flat beans with straight seams. The appearance of this sample has possibly helped to sell the coffee from which it was drawn at the relatively high price realised. Samples No. 130 and No. 84 are very poor-looking samples. No. 107 and No. 83 have a decidedly better appearance and, as we do not know what standard was adopted for valuing these coffees, we cannot say definitely that the market price realised was really its true value and that the relative position of these four samples may not have been exchanged. At any rate, the general tendency of the market price and the specific gravity are in the same direction.

TABLE No. X.

Coorg Coffee.

No.	Price realised	Specific Gravity	Comparative rank in		Remarks
			Sp. Gr.	Price	
133	68	1·258	1	1	
132	62	1·252	2	2	
131	53	1·239	3	3	
86	53	1·202	8	4	The relatively high price is unexplained.
108	52	1·231	5	5	
87	50	1·228	6	6	
110	47	1·236	4	7	Uneven, bad color, somewhat shrivelled.
109	47	1·217	7	8	
88	45	1·175	9	9	

44. Judging by either the appearance or the specific gravity of the sample, it is impossible to explain the relatively high position occupied by sample No. 86. No. 110 is very uneven and on the whole a comparatively poor-looking sample. This doubtlessly explains the relatively low price obtained for it. With these two exceptions the samples would be in the same order, whether classified either according to specific gravity or market price.

TABLE No. XI.

Nilgiris Coffee.

No.	Price realised	Specific Gravity	Comparative rank in		Remarks
			Price	Sp. Gr.	
124	68	1·278	1	1	
125	58	1·275	3	2	
123	60	1·273	2	3	
94	53	1·255	5	4	
122	55	1·251	4	5	
95	43	1·207	6	6	

45. In this table a slight change in relative position of the four samples of intermediate value would occur if classified according to market price instead of specific gravity, but the position of the first and the last would remain unchanged.

TABLE No. XII.

Naidoobatum Coffee.

No.	Price realised	Specific Gravity	Comparative rank in		Remarks
			Sp. Gr.	Price	
104	85	1·277	1	1	
103	68	1·277	2	2	
89	51	1·226	3	3	
90	47	1·218	4	4	

46. In this table specific gravity and market price run in the same direction though the difference in price between samples Nos. 104 and 103 are not indicated by a proportional difference in specific gravity.

TABLE No. XIII.

Nelliampathy Coffee.

No.	Price realised	Specific Gravity	Comparative rank in		Remarks
			Sp. Gr.	Price	
91	61	1·246	1	1	
93	52	1·245	2	2	
92	49	1·212	3	3	

TABLE No. XIV.

Wynaad Coffee.

No.	Price realised	Specific Gravity	Comparative rank in		Remarks
			Sp. Gr.	Price	
120	46	1·248	1	1	
119	43	1·159	2	2	

TABLE No. XV.

Costarica Coffee.

No.	Price realised	Specific Gravity	Comparative rank in		Remarks
			Sp. Gr.	Price	
97	75	1·220	4	1	Strikingly fine looking, large sample, different variety to Nos. 114, 115 and 96.
114	70	1·260	1	2	
115	64	1·260	2	3	
96	60	1·260	3	4	
116	54	1·218	5	5	Similar in shape to No. 1 and doubtlessly of the same variety.

47. As stated above, samples No. 97 and 116 are not the same variety of coffee as the other three samples. They are a much larger, differently shaped and not nearly so flat a bean as the others. They have a much lower specific gravity. No. 97 is a particularly attractive sample.

TABLE No. XVI.

Guatemala Coffee.

No.	Price realised	Specific Gravity	Comparative rank in		Remarks
			Sp. Gr.	Price	
98	67	1·254	2	1	
99	55	1·256	1	2	An uneven and smaller sample than 98.
118	54	1·254	3	3	
117	45	1·235	4	4	

48. No. 99 is an uneven sample and the beans are smaller in size than No. 68. This may possibly account for the much lower price realised for that sample.

TABLE No. XVII.

Nicaragua Coffee.

No.	Price realised	Specific gravity	Comparative rank in		Remarks.
			Sp. Gr.	Price.	
111	58	1·256	1	1	
112	49	1·230	2	2	
113	42	1·203	3	3	

TABLE No. XVIII.

No. 121. San Salvador coffee. Price realised 58. Specific gravity 1·253.

No. 126. Shevaroys coffee. Price realised 58. Specific gravity 1·270.

49. In the above tables there is a general tendency of the specific gravity of the coffee to diminish with the market price though there is no fixed relation between price and specific gravity. It is disappointing that the agreement between specific gravity and price is not closer than it is. But considering that the price is not necessarily an absolutely true index of quality and that there are still some difficulties in accurately determining the specific gravity of coffee, a fixed relation between price and specific gravity could not be expected. It cannot be doubted however that the specific gravity is fairly closely connected with the quality of coffee. And there is every reason to hope that it will be possible to at least compare the quality of successive crops from the same estate, or the crop produced on different parts of an originally uniform field of coffee with each other by determining their specific gravity. And as the object in starting this

inquiry was largely to find some means of readily comparing and recording the quality of coffee produced on different plots of the same experimental field, the results given in the above-tables are very encouraging indeed.

Fertilizers.

50. Twenty fertilizers of varied kinds were analysed during the year. Among these were seven samples of White Castor poonac. As will be noted in Table No. XIX given below, the percentage of nitrogen in these varied from about 4½ per cent to 7 per cent. This difference in quality was largely due to a difference in the percentage of husks these samples contained. As these husks are black they appear as dark flakes in the otherwise white cake. The quality of the cake can therefore be judged to a certain extent by the eye. If the poorest sample of White Castor in the table below is worth Rs. 45 per ton, the best sample is worth about Rs. 70 per ton. The only other fertilizer represented by more than one sample in the table below is Kurdi poonac. Of this there are only two samples, of which the one, No. 32, has just double the value as the other, No. 40. Taking the same valuation as that adopted for the white Castor above, No. 32 would be worth Rs. 64 per ton and No. 40 only Rs. 32 per ton. These figures again indicate the folly of buying white Castor, Kurdi, or any other commercial fertilizer without a guarantee as to quality. A difference of Rs. 25 and Rs. 32 per ton certainly ought to be worth considering. The name of a local commercial fertilizer, especially a poonac, gives at best but an imperfect indication of its quality or value.

51. Of the other fertilizers contained in the table, the wood ashes, although better than some ashes analysed in this Laboratory, contain less potash than might be expected. The bone meal, Hongay poonac and fish are almost up to an average sample, while the Neem poonac is nearly 1¼ per cent above the average of the samples analysed in this Laboratory heretofore.

TABLE No. XIX.

Manures and Fertilizers.

Number	Substance	Locality	Moisture	Loss on Ignition	Nitrogen	Insoluble Residue	Lime	Potash	Phosphoric acid
32	Kurdi Cake ..	Hubli ..	...	...	6·43	...	...	...	...
40	Do ...	Do ...	9·00	87·45	3·22	·63	·48	...	1·08
33	White Castor Cake ...	Coimbatore ...	...	...	5·56	...	...	..	...
42	Do ...	Bangalore	9·49	82·01	6·47	2·61	·73	...	2·62
48	Do ..	Madras ...	7·07	84·94	6·82	2·42	·80	1·12	2·55
50	Do ...	Bangalore ...	...	...	4·53	...	...	...	...
51	Do ...	Do ...	...	...	6·40	...	..	...	...
52	Do ...	Do ...	...	...	7·01	...	...	...	...
53	Do ...	Shevaroys ..	...	...	5·94	...	...	...	...
43	Hongay Cake ...	Bangalore ..	11·21	83·24	3·59	1·62	·81	...	1·19
45	Neem Cake ...	Madras ...	11·83	80·41	5·99	1·20	·92	...	1·60
46	Poonac (probably ippe)	Do ...	12·12	83·40	4·14	1·04	·67	...	1·06
35	Dried blood ..	Ceylon ...	...	...	10·40	...	...	...	...
47	Fish ..	Coimbatore ...	7·15	46·38	6·17	27·38	...	...	7·51
41	Bone meal ...	Bangalore ...	7·92	30·59	3·79	4·35	30·28	...	22·20
39	Wood ashes ...	Hubli ...	2·47	...	...	...	...	2·47	...
49	Saltpetre ...	Coimbatore ...	5·43	...	9·12	...	...	36·76	...
78	Cattle manure ...	Bangalore ...	72·09	7·57	·18	11 89	·31	·24	·09
81	Coffee pulp dried ...	Pollibetta ..	9·23	90·73	2·33	...	1·00	2·17	·39
44	Coffee fertilizer ...	Madras ...	9·57	58·76	5·39	2·55	5·37	...	5·10

Famine Foods.

52. A large number of fleshy roots, tubers, bulbs, and succulent stems and leaves were sent in under the head of "Famine Foods" by the Revenue Commissioner, by the Conservator of Forests, and by Deputy Commissioners of Districts for analysis. Mr. Cameron, Superintendent of Government Gardens, kindly undertook to name the specimens sent in so far as the parts of plants supplied would permit. The botanical names are all given on his authority. The vernacular names were supplied by the persons sending in the samples. Out of the samples sent in 41 were in a condition which justified their being preserved for analysis. These analyses are in course of progress and in 31 the percentage of nitrogen has been determined. The results are given in the table below. The moisture in the air-dried samples, the starch and the crude fibre will be determined as time permits. Unfortunately it will be impossible to make any determinations as to palatability and digestability or to determine if these "foods" have any pathological action.

TABLE No. XX.

Famine foods.

No.	Kanarese name	Botanical name	Remarks of officers who sent in the samples	Nitrogen per cent
134	Guttigadde ...		The edible part is the tuberous of a herbaceous plant found in the shallow tanks of maidan districts. The tubers without roots washed well, skin pealed off, boiled and eaten mixed with jaggory, also dried, pounded, the fine flour mixed with ragi flour and made into balls and eaten.	2·86
135	Bendle soppu ...	Erythroxylon monogynum .	Leaves dried, boiled in water, mixed with salt and condiments and eaten.	1·95

TABLE No. XX—Contd.

No.	Kanarese name	Botanical name	Remarks of officers who sent in the samples	Nitrogen per cent
136	Gyadari or Devadari soppu.	Ægle marmelos.	Leaves dried, pounded into flour, mixed with ragi flour; cooked and eaten; also used as a curry.	1·83
137	Navare genasu .			·86
138	Sal genasu ...			1·31
139	Karane genasu .		The roots are the staple food of the Jane Kurubars.	1·58
140	Kall genasu ...			1·08
141	Akki genasu ...			1·09
142	Adavi genasu...	A species of Dioscorea.		1·17
143	Nose gadde ...		Tubers washed in water, ground with tamarind and made into cakes.	1·79
144	Kathale gadde .		Cut into pieces and boiled with a paste of tamarind, dried in the sun and eaten.	·67
145	Eachala hannu .	Phoenix sylvestrius.		·72
146	Bettada eachala hannu.	Phoenix farinifera.		·63
147	Jambu neralikayi.	Eugenia Jambulona Var : obtusifolia.		·82
148	Kare soppu ...	Canthium Parniflorum.		2·27
149	Kasavin gadde .	Alacasia antiquorum.		·91
150	' aragenasu ...	Manihot utillisima.		·60
152	Yele genasu ...			1·48
153	Honagone soppu	Alternanthera sessilis.		3·07
156	Tangadi huvu...	Cassia auriculata.		1·47
157	Kesavin dantu.	Alacasia antiquorum.		1·05
158	Chandra mallige gadde.	Mirabilis Jalapa		1·03

TABLE No. XX—concluded.

No.	Kanerese name	Botanical name	Remarks of officers who sent in the samples	Nitrogen per cent
159	Bitharu kalale (Bamboo shoots)		The tender portion at the core is eaten; pickled with limes; also eaten as a curry.	4·23
160	Vendalaga soppu.	Hydrocotyl Asiatica.		1·53
161	Kondal genasu .			·82
162	Noren genasu ...	Dioscorea aculeata.		·80
163	Seebe gadde ...			1·12
164	Byle genasu ...			·72
165	Bikki kayi ...	Gardeni gummifera.		·68
166	Makali beru ...			·40
167	Gonee fruits ...	Ficus Mysoriensis.		1·16

INSECT PESTS AND PLANT DISEASES.

53. The principal insect pests which have come under the notice of the Department during the year were locusts (*Acredium peregrinum*), kumbli hulas, Green-Mealy Scale on Coffee shade trees (*Pulvinaria psidii*), Coffee borer (*Xylotrechus quadripes*), Plant lice, Cocoanut Palm borer (*Oryctes rhinoceros*), various insects attacking rice which could not be identified and a Tamarind Scale (*Aspidiotus*).

54. *Grasshoppers.*—Appeared in the Tumkur and Shimoga Districts. They were not the same as the locusts which did such damage in parts of the Bombay Presidency.

55. *Plant lice.*—Were apparently much more numerous than in former years. A spray of kerosine emulsion is very effective in fighting this pest. The emulsion is made as stated in Bulletin No. 1 (Notes on Entomology) of this Department by cutting into thin slices one pound of some good bar soap, dissolving this by putting it in one gallon of boiling water, continuing to heat the water if necessary and stirring often. When the soap is dissolved two gallons of kerosine oil are gradually poured into the soap solution;

during this process the soap solution is thoroughly churned to tranform the kerosine oil into an emulsion. Before use one part of this emulsion is diluted with 9 to 10 parts of water. The points to be principally watched are (*a*) that the water used for preparing the emulsion is *soft* (free from salt or lime) and (*b*) that when the emulsion is diluted there are no little particles of kerosine oil floating on the surface. For if there are little particles of kerosine oil visible, the emulsion is liable to kill tender plants as well as the plant lice. When the emulsion is well prepared there is no danger of this. The best time to apply this emulsion is probably the early morning or during cloudy days.

56. Mr. Lefroy, Entomologist to the Government of India, very kindly visited Santaveri, Koppa and some other parts of Mysore to study the Green Mealy Scale doing such a large amount of damage to shade trees of coffee in some parts of the State. He discovered that a large number of the eggs of this pest hatched after they had fallen to the ground (with the leaves on which they had been laid). Afterwards the tiny young insects crawled up the stems of the trees and on reaching the tender shoots and foliage fed on these as their parents had done. To prevent these tiny Scale insects from climbing the trees Mr. Lefroy recommends "Paint a four inch ring of tar round the trunk of attacked trees, below the lower branches, but above the coffee." This apparently proved satisfactory. For fuller information on this and other South Indian Scale insect pests those interested must consult Mr. Lefroy's Preliminary Report on the subject in Bulletin No. 2 of the Imperial Department of Agriculture. A. H. Jackson, Esq., Manager of Dubarry Estate, Coorg, reports very good results from the application of "lime sulphur" for "Mealy bug" attacking the roots of coffee trees. This pest is also treated in Mr. Lefroy's Bulletin referred to above.

57. *Root diseases of Coffee.*—Dr. Butler, Cryptogamic Botanist to the Government of India, accompanied by the Agricultural Chemist to the Government of Mysore, visited

Saklespur and Koppa to study the "*Stump rot of Coffee.*" The results of this investigation indicate that in addition to the so-called Stump rot of Coffee (*Rosellinia*) which appears to be generally distributed throughout the coffee-growing districts (and which can be checked by digging a trench about 18 inches to 2 feet deep well outside the affected part and liming the affected area) there exists another root disease in various parts of the coffee growing districts; this has been provisionally named "root rot." The chief differences to the naked eye are—

(*a*) The areas affected by *stump rot* are generally well defined and often the dead stump or some large dead root of a shade or jungle tree can be found somewhere in the affected area. The trees die in a comparatively short time after they are affected and seldom are living trees found surrounded by dead ones.

On the other hand the areas affected by *root rot* are not sharply defined. The trees get "sticky" (stick-like) and gradually die in an irregular patch. Trees here and there are still alive, while others farther removed from the centre of the affected area are dead. There appears to be no decaying stump or root to which this disease can be traced. The trees do not die so quickly and are generally still alive when those beyond them show visible signs of being attacked.

(*b*) The roots of the affected trees also vary. The tap-root of a tree affected with *stump rot* has generally some soil clinging to it, and when this is lightly scraped off with a knife no sharp line of demarcation can be found between the soil and the bark of the root. The outside bark is impregnated with soil, is dark in colour and appears gritty when cut with the knife. Nearer to the wood it is mottled in appearance. In *root rot* the soil does not cling to the tap root nearly so much. As a rule only a part of the tap root is discoloured on the outside and this discoloured portion has none of that peculiar impregnation of soil on its outside and the discoloured portion is practically of a uniform dark brown tinge and

occasionally extends into the wood. The root rot has as yet not been identified with certainty and no effective treatment can be given at present.

There are still many places in which "root rot" is unknown, and the greatest care should be taken to prevent its introduction into unaffected localities. It is most likely due to a fungus which spreads in the soil. Managers of Estates still free from this disease should on no account import plants from an affected estate, as these are liable to carry infection either themselves or through particles of soil still adhering to them.

58. Another root disease is reported from the Shevaroy Hills which appears to be quite distinct from the two enumerated above. But so far we have only seen the roots of the trees affected by this disease and have had no opportunity of examining it more closely.

59. *Kole Roga.*—During his visit to Koppa Dr. Butler examined a large number of areca palms suffering from Kole Roga and determined that the disease is due to a *Colletotrichum*, a family to which a number of the worst plant diseases belong. One form of spores which spread this disease is only produced in water and the mehtod of covering the bunches to keep out the rain appears therefore to be sound and should be practised as much as possible. The Agent of the Sringeri Matt recommends thin zinc sheets for this purpose. Generally a part of the areca leaf itself is used for the purpose.

60. *Spike disease in Sandal.*—In the second annual report of this Department reference was made to a disease of sandalwood named by Mr. McCarthy, Deputy Conservator of Forests of Coorg, who first noticed it, "Spike." The diseased branches continue to grow uninterruptedly. The leaves of these branches become narrower, thicker, stiffer and reduced in size as the disease advances. The "internodes" (distance between each pair of leaves) in the fresh shoots are shorter. The disease spreads, branch after branch shows the characteristic signs of the disease until finally the tree dies. Mr. McCarthy has described

the external appearance of disease very fully in his report. Mr. Barber and Dr. Butler have studied it independently in Coorg last year. Mr. Barber's report is published in the Indian Forester, January 1903. This year Dr. Butler, Cryptogamic Botanist to the Government of India, Mr. Barber, Government Botanist, Madras, and the Agricultural Chemist to the Government of Mysore spent two weeks together studying this disease at various places in the Mysore District, principally at Yelwal and Bilikere. Mr. McCarthy, Deputy Conservator of Forests for Coorg and Rai Bahadur M. Muthannah, Conservator of Forests, Mysore, were also present for a time. The roots of many sandalwood trees were dug up. A root on the side of the tree bearing spiked branches was selected. This was followed from the stem as far as possible, sometimes right to the haustoria. Invariably it was found that these roots were dead before the haustoria were reached. Mr. Barber made a macroscopic and external examination of these roots, and Dr. Butler examined sections microscopically. But no fungus or other micro-organism was found in the roots to which this disease could be ascribed. As pointed out by Dr. Butler, the disease somewhat resembles "Peach yellows" and like that disease is undoubtedly a very difficult one to deal with. Mr. Barber has noticed a malformation resembling spike disease of sandalwood in some other plants, including an annual, and has preserved specimen of these in his herbarium in Madras.

An attempt was made to inoculate rather stunted young trees in a part of the Bilikere Plantation. Dr. Smith in his experiments on "Peach yellows" in the United States of America has been successful in inoculating healthy peach trees by budding them with buds taken from diseased trees as reported in Bulletin No. 1 of the Division of Vegetable Pathology.

As spike disease somewhat resembles "peach yellows" an attempt was made to inoculate healthy sandal trees by budding them with buds taken from diseased trees. Some were taken from apparently healthy branches on trees showing the first symptoms of the disease. Others

were taken from the diseased branches of diseased trees. The budding was done by the most successful budder at the disposal of Mr. Cameron, Superintendent of Government Gardens in Mysore. As checks some buds taken from undoubtedly healthy trees were budded into healthy trees. When examined in February five months after the budding was done, not one of the buds had taken and not one of the budded trees showed any signs of spike disease. No trace of spike disease was found on any of the other trees experimented with. In some of these the wood was exposed on some of the thin branches by cutting away a little piece of bark and a thin layer of the underlying wood. To this was tied a little larger piece of bark with a part of the underlying wood taken from a diseased branch of sandal. Some of the larger roots of other trees were exposed, pieces of diseased roots placed in contact with them and the earth replaced. As already stated no spike was visible in any of these trees four months later. In the same plantation at some considerable distance removed from the spot where the budding was done, were a few spiked trees. These were surrounded by a trench about two feet deep in the hope that possibly this trench might prevent the spread of the disease. In February the disease had not appeared outside the trench. But the following September it had spread beyond it.

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A. LEHMANN,
Agricultural Chemist.

MGCPB—1000—25-5-05.

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SIXTH ANNUAL REPORT

OF THE

AGRICULTURAL CHEMIST

FOR THE YEAR 1904-1905.

Kanarese and English Reports and Bulletins of the Department of Agriculture will be sent free to Planters, or Raiyats, who apply for them, so long as the supply lasts.

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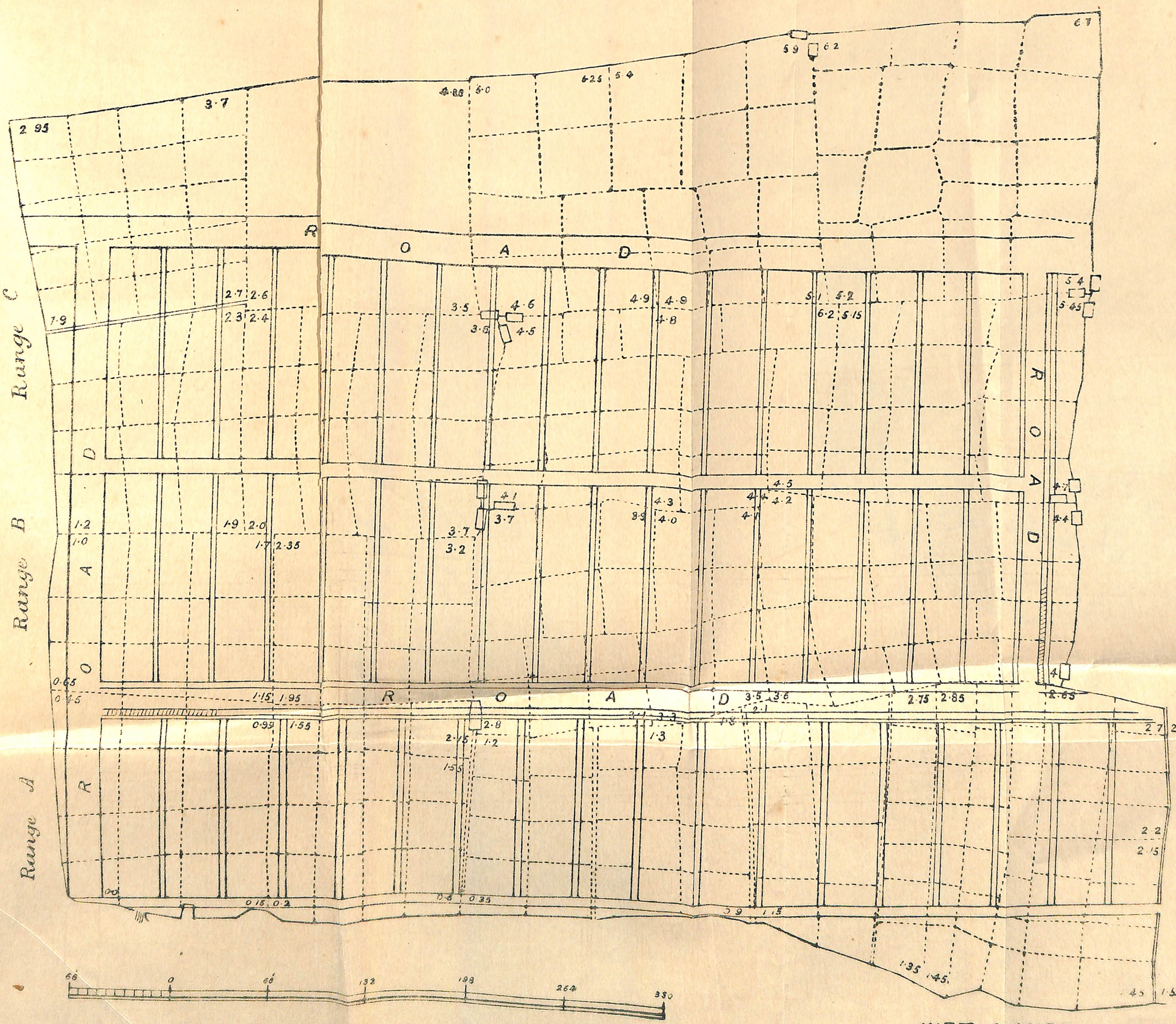
1906.



Scale 66 feet or 100 links to one inch.

The figures indicate drop (in feet) from highest point of field.

WET LANDS

OF

Experimental Farm at Hebbal.

addition of wetland
— " — of dry lands

SIXTH ANNUAL REPORT
OF THE AGRICULTURAL CHEMIST
FOR THE YEAR 1904-05.

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PART II.

15. This is the only part of the report intended for distribution. Part I does not contain information of general interest to the agriculturists of Mysore.

Experimental Farm.

16. Some years ago lands were selected for an Experimental Farm by the Agricultural Chemist, and were visited by and approved of at the time by Sir P. N. Krishna Murti and Mr. Mollison. But at the time the plan to open an Experimental Farm fell through. These lands were acquired and handed over to this Department in January 1905. They consist of twenty-one acres and nineteen guntas of dry and garden lands and nine acres and twenty-seven guntas of wet land under the Hebbal tank, five miles from Bangalore. The dry land which is almost adjoining the wet area, is lying between the Yelahanka road and the Military reserve just south of the Hebbal tank. It is a ferruginous loam representing, as far as can be judged by the eye, fairly well the average soil of the State. The soil is as uniform as could be found in the neighbourhood of Bangalore, but gradually changes a little from the road to the Military reserve, and from the southern boundary to the tank. It slopes gradually and uniformly towards the tank. Enclosed is a map showing the original fields and

the plots as laid out at present. These plots are one-tenth of an acre each, being fifty links wide and two hundred links long. The land was previously owned by several raiyats who have naturally treated it somewhat differently in regard to manuring and cultivation. The various pieces used as garden lands are of course in much better condition than those used for ordinary dry crops. This causes considerable temporary differences to exist in some of the plots in addition to probably slight permanent differences. These temporary differences, it is hoped, will disappear in the course of a year or two. If any permanent differences exist, they will have to be compensated for by a judicious disposition of the duplicate plots. To get a clear insight into the differences actually existing between the various plots intended for experiments, all the plots were treated exactly alike this year. The crop growing on them is ragi. The grain and straw produced by each plot will of course be weighed separately. And if the results are sufficiently uniform over a sufficiently large part of the area that area will be used for experiments next year. The remainder will be again placed under uniform treatment. Just what the nature of the experiments will be cannot of course be determined until after the present test crop has been reaped and weighed.

17. A part of the dry lands nearest the tank, which is not quite as uniform as the remainder, is already excluded from the experimental ground proper. On part of this various garden and field crops have been grown this year. The seeds of most of these were kindly sent by the Bombay Department of Agriculture from the Experimental Farm at Manjri. These crops are doing well on the whole though some of them, notably one otherwise very promising variety of brinjals, have suffered very much from disease. On an apparently even part of this non-experimental area, ragi was sown at various times to get a general impression of the effect the time of sowing has on this crop. In this experiment the rain is of course the most important factor. Sometimes there is enough rain to enable ploughing, but the soil gets too dry by the time the ploughing is finished to permit the grain to germinate. After the next

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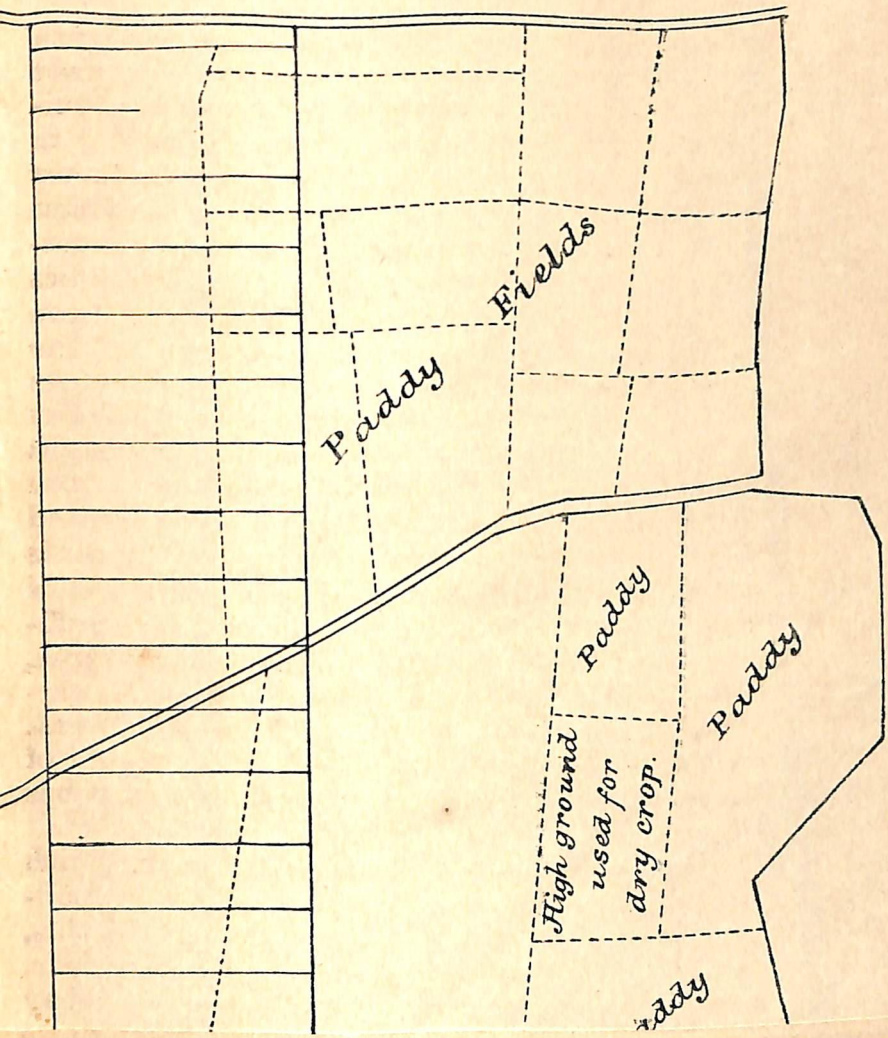
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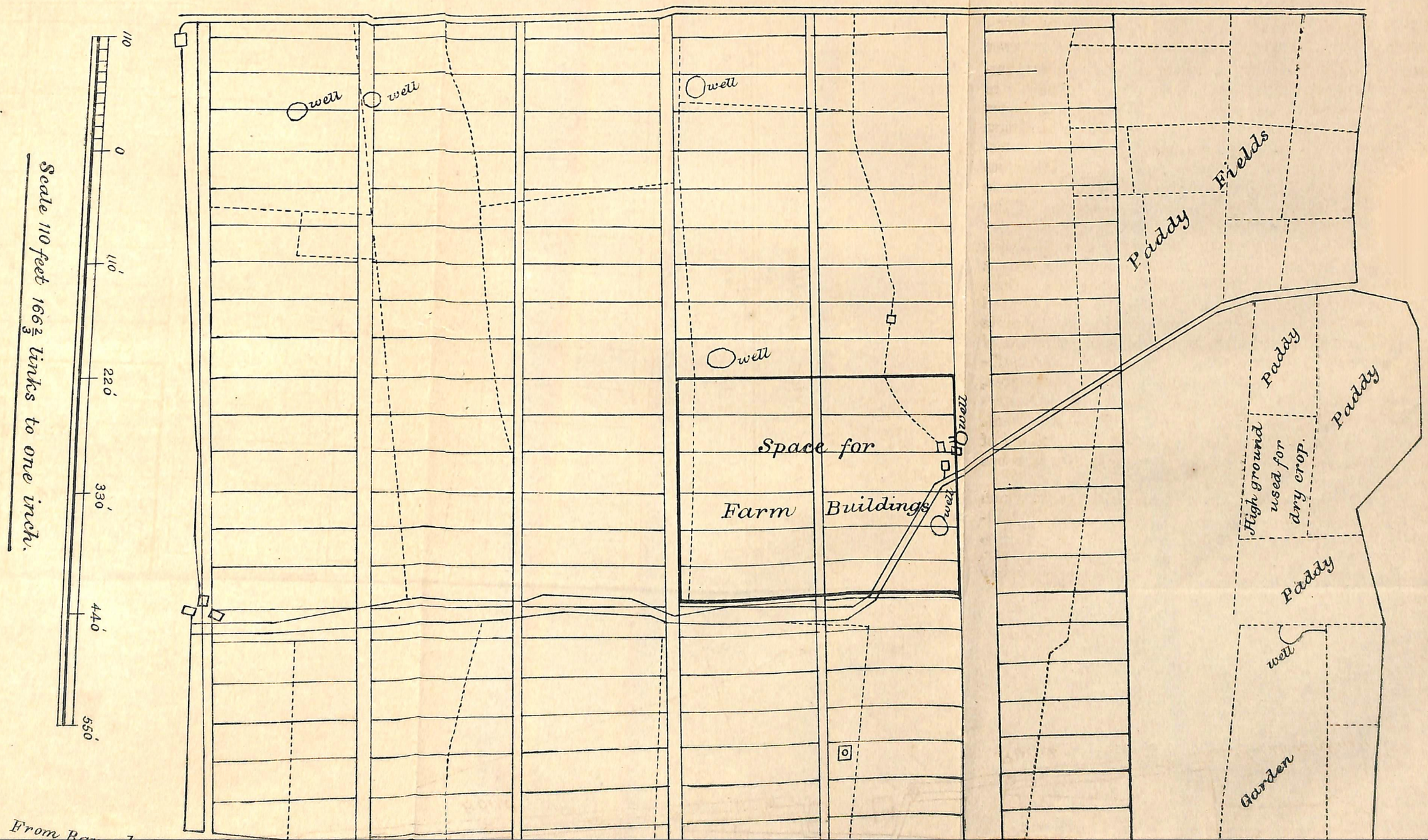
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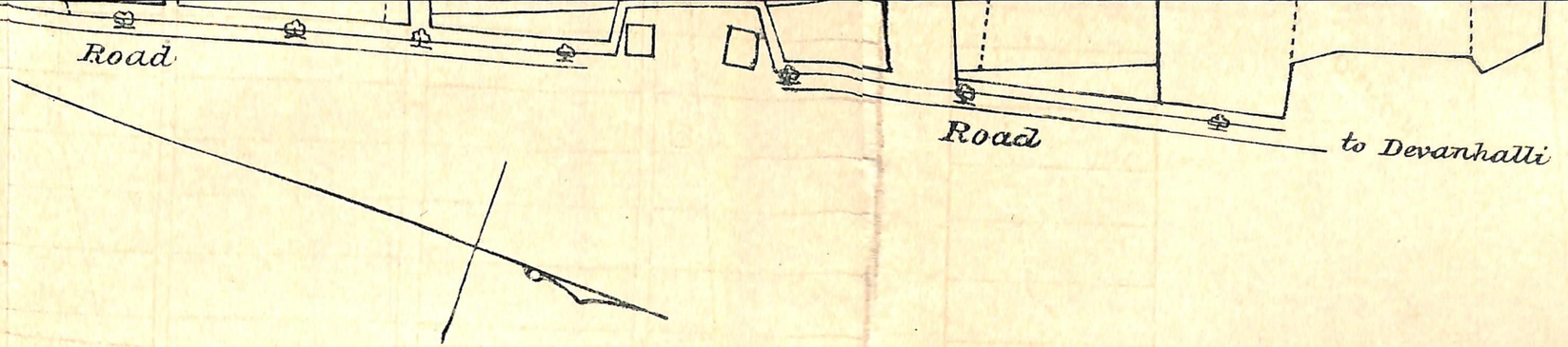
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rain some time is again required before the sowing is completed. To test if it would be possible to sow as soon as the ploughing is finished, even if the ground is too dry, and thus permit the crop to get the full benefit of the next shower of rain, was one of the objects of these experiments. In addition to the danger that the seed may germinate and afterwards die for want of moisture, there is the drawback that if the seed does not germinate, it may be eaten by ants or some other pest. To overcome this the grain was covered by a very thin film of kerosene oil. A little of this oil was poured on a heap of seed grain and this was thoroughly stirred so that each grain although appearing dry had a distinct smell of kerosene oil. To test if this thin coating had any injurious effect on the germination or the future growth of the plants, a second plot was sown at the same time with seed not treated in this way. Within a week after the first set of two plots had been sown, several good showers of rain fell. The grain treated with kerosene oil came up quite as well as that without it, and as far as appearances go at present the crop on the later sown plots is not likely to be as heavy as on those sown earlier. Next year, these experiments will be begun earlier.

18. The so-called experimental area, that on which it is hoped to conduct comparative experiments hereafter, was ploughed twice with a one-horse Canadian plough, and as it was fairly weedy in parts, a Planet Junior horse hoe was used instead of a harrow before seeding. No manure of any kind was applied. But the crop looks very much better than that on the adjoining field which received a dressing of cattle manure and was cultivated in the usual way. To what this very considerable difference is due, it is at present impossible to say.

19. The wet area was also divided into one-tenth acre plots. One range is at a considerably higher level than the remainder and on it the soil is decidedly lighter, being a ferruginous loam not much heavier (or stiffer) than that of the dry area. On this range it is intended to conduct experiments with sugar-cane. The remaining ranges are a clay loam gradually becoming a little heavier towards the

north-east. The land is the most south-westerly block under the Hebbal tank and slopes gradually towards the north-eastern corner. Each range and each plot can be irrigated and drained independently of the other. The plots are separated by bunds three feet wide and the top of these bunds serves as a path. The entire so-called experimental area has been put under the same variety of paddy to test the uniformity of the soil in the same way as has been done for the dry lands with ragi. The accompanying map gives the original subdivisions of these lands and the present experimental plots. The original differences in levels are also given. Care has been taken to have the present boundaries of the plots coincide as nearly as possible with the boundaries of the former fields, especially where any marked difference existed in the levels of the old fields. Still some re-levelling had to be done, and the effect of this is quite distinctly visible in the crop growing at present. But with the exception of a little filling in, which was necessary in the future sugar-cane range, no earth has been removed from or added to any of the plots. The levelling has been entirely in the plot itself, in fact in each individual one-third or half section of the plot (for all the plots are divided into two or three sections to reduce the amount of levelling required). And the poorer stand due to the removal of part of the surface soil in the higher part of the section is compensated for, to a large extent at least, by the better stand of paddy in the part where this soil has been added. The paddy was all grown in seed beds outside the experimental area and transplanted. Thus far, it has been practically free from disease or insect pests and promises to crop well. Of course no manure of any kind has been used.

20. Temporary buildings have been erected on the Farm, which will, it is hoped, last until the permanent buildings which have been sanctioned are built. They are necessarily very small. A rain-gauge, kindly supplied by the Meteorological Department, has been set up, and some other Meteorological instruments, such as sunshine recorder will, it is hoped, be added in time.

Laboratory Compound.

Ragi.

21. *Ploughing.*—The experiments with ragi were this year a little more satisfactory than last year. Still the results require to be taken with almost as much reservation as was necessary last year. The crop is better all round, on the manured as well as the unmanured plots. On the unmanured soil the difference in favor of the plot cultivated with the Canadian plough has largely disappeared when compared with the plots ploughed with the native implement. But on the land manured with cattle manure (on which practically no difference existed last year) there is this year a decided difference in favor of the Canadian implement. The plots which received cattle manure and were cultivated with the Mysore plough gave at the rate of 975 lbs. of grain per acre, those ploughed with the Canadian implement gave at the rate of 1,437 lbs. of grain per acre.

22. *Manuring.*—Last year, the cattle manure plots gave at the rate of only thirty-one and one-third pounds of grain for every one hundred pounds produced by the commercial fertilizer plots. This year, they gave relatively much better returns, producing at the rate of eighty-six and a half pounds of grain for one hundred pounds grown on the commercial fertilizer plots, but the amount of commercial fertilizer used contained more plant food than the cattle manure. Contrary to expectations there was no indication that any of the manures applied last year had any effect on this year's crop, not even the cattle manure. But owing to the uneven nature of the soil, it is impossible to detect slight improvements in crop due to the after-effect of the manures used last year even if they existed. The already small plots manured last year were divided, one-half remained unmanured, the other half was manured as in the previous year. If the soil had been uniform, any after-effect of last year's manures should have been noticed when comparing these half plots which had received manure last year, but not this year with the plots which had received

no manure at all. But while two unmanured plots gave exactly the same amount of grain (at the rate of 1,225 lbs. per acre) the other two plots gave decidedly less (357 lbs. and 712 lbs.). With such large difference in duplicate plots it is out of the question to attach much weight to any of the results. The average of these four plots is 879 lbs. of grain per acre, that of the six plots manured last year but not this year is just 800. No after-effect of the last year's manures can therefore be detected. The average of the corresponding manured plots is, however, 1,393 lbs. per acre.

23. One plot which received a double quantity of commercial fertilizer both last year and this year, showed that too much manure had been applied, as it produced a very heavy crop of straw (nearly five and a half tons per acre) and practically no grain (595 lbs. per acre). The average of the plots dug deep (about two feet) was :—unmanured 1,212 lbs. per acre, manured with commercial fertilizers 1,475 lbs. Apparently, ragi favors deep cultivation. But of course all these experiments are only preliminary and conducted on much too small a scale and on too uneven a soil to carry any weight except as indications for future experiments on the Experimental Farm.

24. The maximum crop for the variety of ragi (Halubile) used in these experiments appears for this season, on this soil, to have been about one ton of grain (2,225 lbs.) and a little over five tons of straw (11,375 lbs.) per acre.

25. The variety giving best returns this year was Balepatte, which produced at the rate of about one and two-thirds tons (3,750 lbs.) per acre of grain and nearly six and one-fourth tons (13,800 lbs.) of straw. This variety stood second last year, and the variety which headed the list last year, Jenumuddina ragi, stood third this year. But here too the plots are too small, and possibly too uneven, to draw any reliable conclusions. The crops are, however, very heavy for all the varieties. There is also an indication that the Madayangiri and the Dodda varieties would do relatively better when treated not as liberally as these plots have been treated.

26. *Sweet potatoes.*—The sweet potatoes did not do quite as well as in the previous year. The new Jersey gave exactly the same yield as the year before (at the rate of 14,175 lbs. per acre) and headed the list instead of being second as last year. The Virginia and the Nansimond gave at the rate of 8,600 lbs. and 8,760 lbs. per acre this year.

27. *Ground-nuts.*—The ground-nuts were all badly diseased this year. The Virginia instead of heading the list as it did last year with 10,100 lbs. per acre came last with only 3,550 lbs. per acre. The Japanese gave 4,100 lbs. instead of 8,750 last year, and the Pondicherry, 4,550 instead of 6,925 last year. The relative positions are therefore exactly reverse to those of the previous year. But of course, when diseased as they were this time, the returns would be of little value even if the soil had been absolutely uniform. The same seed will be sown next year, but that used for one-half the plot will be treated for five minutes with a one per cent solution of copper sulphate to see if such treatment will reduce the disease.

28. *Buildings.*—The out-buildings containing store rooms, implement rooms, godowns for two servants, and a potting room for the pot-culture house are practically completed. A pot-culture house is in course of construction. This is an iron structure which is to be covered on all sides with wire netting to keep out birds and other small animals which cannot pass through a half-inch mesh. In this pot-culture house will be a light railway track on which small cars can be run. On these cars will be the pots in which the various experiments are made. They are placed on cars so that at times of heavy rains or winds they can be easily run under shelter and at times when there is no danger from birds or other small animals they can be run out into an open yard if such should be desirable. Pot-cultures are quite a new line of experiments for India, or, as far as I know, any other tropical country. Dr. Leather has tried them on a small scale at Dehra Dun last year without a railway track and cars, but found

Pot-culture house.

that these appliances are necessary for satisfactory work. It is, at present, impossible to say what kind of shelter will be required here. In Europe and America, these shelters are constructed of glass. But it appears likely that such would not answer under a tropical sun. As an experiment, the potting room in the new out-buildings will be used, to begin with, as a shelter for the plants. By replacing some of the ordinary tiles in the roof of this potting room by glass ones it may be possible to get enough light without getting too much heat. After finding out what is likely to answer for this purpose in this climate, it is hoped that the necessary changes or additions can be easily made.

29. In pot-cultures, the soil is all thoroughly mixed before being filled into the pots and thus the inaccuracies arising from an uneven soil are to a very large extent done away with. The other advantages and disadvantages will be explained after the completion of the house and after some work has been actually done in it.

30. *Compound wall.*—The compound wall protecting the small experimental plots in the Laboratory compound is also practically completed.

Sugar and Sugar-cane.

31. The experiments conducted with sugar-cane were this year confined almost exclusively to the manufacturing side of the sugar industry. Chief of these were the manufacture of raw centrifugal sugar, the determination of the amount of juice left in the cane when milled, as carefully as possible, with a local, three roller, iron bullock mill, and determining the extent of loss sustained by keeping the juice after being milled or the cane after being cut.

32. *Ratoon crop.*—The cane for these experiments was grown in the laboratory compound from the stubble of last year's crop. It is therefore a ratoon crop. The reasons for doing this were many ; one of the chief of these was to see how a ratoon crop would grow here, and to find out if there were any very sound or strong reasons for not following in India the general practice of Cuba and

other cane-sugar-producing countries. Some of the other reasons were—

(*a*) to get, if possible, the next crop in a little over a year's time, the variety grown was, as stated last year, one of the so-called eighteen months varieties ;

(*b*) to avoid the necessity of planting the cane without the supervision of the Agricultural Chemist who was on leave, and incidentally,

(*c*) to save the expense of planting.

The previous crop was cut in the latter part of March 1904. The ground was thoroughly dug and manured as in the previous year. Surface irrigation was given whenever necessary. The ratoon crop came up well. As far as could be judged by the eye, there were a larger number of stalks but shorter, thinner and shorter jointed. The white ants did quite as much, if not more, damage than in the previous year. The cane was wrapped as had been done the year before, but notwithstanding this and the fact that the canes were shorter, it did not appear to stand as erect at the time of cutting as the crop before it had done. But as one season's crop cannot be closely compared with another produced the year before or the year after, these differences as well as the difference in yield can only be taken as indications. They are not experiments, and only serve as indications for future experiments. Moreover, actual field experiments, no matter how carefully conducted, have to be repeated a large number of times before the results obtained can be considered as reliable. When stating, therefore, that this year's ratoon crop was almost exactly three-fourths of the crop produced last year, this does not imply that on this identical piece of ground this particular variety of cane will give as a first ratoon crop three-fourths of the crop it would have given if it had been planted out that season. But it indicated that it is well worth trying experiments with ratoon crops, especially as in this case the difference in the weight of the cane is to a large extent compensated for by the difference in time the "crop" has been occupying the land. The amount of juice obtained

from one hundred lbs. of cane was very little more in 1903-04, than it was this year from the ratoon cane; being 67·64 lbs. in 1903-04 and 65·3 lbs. this year from the ratoon crop. The difference in the two years' crop is also influenced to some extent by the fact that this year about one-fourth of the field was purposely allowed to get overripe to see what influence this would have upon the composition of the cane and the quantity of the jaggory (or the sugar) boiled from the juice. During these three months probably very little growth took place, but a lot of the canes were destroyed by white ants, and possibly also by rats.

33. *Ripening of Cane.*—To find out when the cane was ready to be cut, and, more particularly, to study the difference in the composition of the cane during the latter stages of its growth, six average canes were cut at different times and analysed. The first sample was taken on January 22nd. To form some idea of the differences which existed in the more mature and the younger canes on the same plot on the same date, three samples of six canes each were taken on that day. One of these samples represented, as nearly as possible, the average of the plot; another, canes which were slightly below the average, and the third was composed of six canes above the average. The composition of the juice of these three samples of cane and that of the juice of the succeeding samples is given, together with the date on which these samples were taken, in the following table No. I :—

TABLE No. I.

Showing composition of juice of canes at various stages of growth.

Ratoon cane—previous crop cut in April 1904.

No.	Date of cutting	Glucose per cent	Sucrose per cent	Total solids per cent	Remarks
270	22 XI 04 ..	3·04	9·5	12·8	From six canes below the average
269	Do ...	2·47	10·1	13·4	From six canes of the average
271	Do ...	2·17	11·75	14·6	From six canes above the average

TABLE No. I—*concld.*

No.	Date of cutting	Glucose per cent	Sucrose per cent	Total solids per cent	Remarks
272	6 XII 04 ...	1·33	14·1	16·0	From six average cane
273	22 XII 04 ...	1·33	14·95	17·0	Do
274	4 I 05 ...	1·16	16·5	18·3	Do
275	18 I 05 ...	·85	18·4	19·5	Do
276	31 I 05 ...	·93	18·2	19·6	Do
277	14 II 05 ...	·69	19·6	20·9	Do
278	21 II 05 ...	·62	19·5	20·9	Do
279	28 II 05 ...	·53	20·0	21·0	Do
280	21 III 05 ...	·40	21·4	22·4	Do
281	1 IV 05 ...	·54	19·6	20·9	Entire plot
302	8 IV 05 ...	·70	19·8	21·1	Do
318	17 IV 05 ...	·67	18·4	19·8	Do
360	26 IV 05 ...	·54	...	...	Do
362	9 V 05 ...	·37	...	...	
363	19 V 05 ...	·32	17·5	18·0	
364	26 V 05 ...	·47	17·5	18·8	
365	3 VI 05 ...	·31	16·0	17·0	
366	10 VI 05 ...	1·00	14·9	16·2	
367	17 VI 05 ...	·65	15·6	16·8	
368	24 VI 05 ...	·55	16·0	17·3	
369	1 VII 05 ...	·56	16·0	17·6	

In the above table samples up to No. 280, inclusive, were taken as described above. These show very clearly the decrease in the percentage of glucose and the increase in total solids and sucrose, or cane-sugar, in the process of ripening. (Glucose or reducing sugar is a name given to a group of substances which, if present in jaggory, cause it to run or sweat in damp weather in proportion to the amount in which they are present, and are very objectionable from a sugar-refiner's point of view. Sucrose, or cane-sugar, is the principal substance next to water found in the juice of sugar-cane. Pure white refined loaf sugar contains practically nothing but this kind of sugar. It is the only substance in sugar-cane which is really wanted. The more of this and the less of every other substance the sugar-cane contains, the better it is, other things being equal, for sugar-making. The total solids mentioned above include everything but the water found in the sugar-cane juice. The nearer the figure given in this column agrees with the figure given in the column headed sucrose the better). The uniformity of the decrease of glucose and increase of sucrose and total solids as shown in the table above is surprising, considering the difficulties there are in taking representative samples. But when comparing these figures with samples Nos. 281, 302 and 318, which were taken when milling the entire crop, it is evident that the samples No. 280 and those preceding it, though very well taken, are a little above the average. Samples No. 363 and those following it, were taken two months or more after No. 280 (which is the best sample in the list). These samples are more striking in their decrease in cane-sugar and total solids than in their increase in glucose. This is especially worthy of consideration when noting the composition of the juice extracted when the entire crop of the cane was being harvested. But to this point I shall have to refer again later on. The only sample in which there appears to be a considerable increase in glucose is No. 366. As it contains one per cent of this substance or nearly twice as much as any of the other samples under consideration, there is evidently something wrong here. It may have been that this sample was not as promptly milled after the cane was cut as the other

samples were. But this is a mere conjecture which is based on the results of some other work. There is no direct indication of any kind to prove that this conjecture is correct.

34. *Boiling of jaggory.*—The chief object of this year's sugar-cane experiments was, as stated before, to produce a raw centrifugal sugar. But as a hand centrifugal is very hard to work and as the centrifugal used this year was made for general laboratory work and not specially for sugar-making, the larger part of the juice was again boiled to jaggory. In the tables given below, the composition of the juice is given first and below it the composition of the jaggory produced. All the liming done was tested with red litmus paper. In the samples marked "fully" limed, slaked lime of the consistency of cream or very thin gruel (canji) was added to the entire mass of the juice intended to be boiled into jaggory. After a little of this slaked lime had been added, the juice was thoroughly stirred and a piece of red litmus paper held into the juice for nearly half a minute. If no change took place in the colour of the litmus paper other than that which would be produced if it were dipped into unlimed juice, more lime was added, again stirred thoroughly and tested with the litmus paper. This was repeated until a faint but *distinct* change of colour could be seen in the colour of the litmus paper by the red having changed into a faint blue. The slight difference in the appearance of the litmus paper caused by the colouring matter in the juice must not be mistaken for this change of colour of the litmus itself when juice is sufficiently limed. To avoid such a mistake, it is necessary to learn by experience the effect produced by dipping a piece of red litmus paper into unlimed juice and to learn to distinguish this from the change produced when just enough lime has been added. Care must also be taken that the litmus paper is fresh and not already partially discoloured by having come into contact with anything containing alkali before use. It must not have the slightest tinge of blue but be quite decidedly red. In the samples marked "half" lime, all the juice required for the boiling was thoroughly mixed,

Liming.

half this quantity was poured into the pan before liming, the remaining half was limed as described for full liming and afterwards also poured into the pan and mixed with the portion previously in the pan before boiling. "Three-quarter" limed means that one-quarter of the juice was poured into the pan and the remaining three-quarters limed as above; and in those marked "quarter" limed, only one-fourth of the total juice required for boiling was limed as already described.

35. *Pan used.*—To prevent the discolouration of the first samples of jaggory from the rust of an iron pan, a copper pan was used this year. It had the ordinary shape used by the raiyats of Mysore and was six feet in diameter at the top, three and a half feet at the bottom and thirteen inches deep.

36. *Furnace.*—The furnace was in the corner of one of the rooms in the new out-buildings of the Laboratory and had proper fire bars, furnace doors, ash pit and chimney. But as no experiments were made in regard to the fuel required, these and some other improvements need not be considered here.

37. *Filtering.*—Before liming, all the juice was passed through a piece of ordinary "long cloth" placed in a basket of wire netting to separate from it all little bits of cane and other suspended matter. And just before the juice came to a boil the scum which had risen to the surface and is technically known as the "blanket" was skimmed off by means of a large copper spoon with a long handle specially made for the purpose. This scum was put in another basket of wire netting lined on the inside with a piece of "long cloth." Through this the juice gradually dripped out and the bulk of the scum remained behind. The skimming was continued from time to time until the juice had been boiled down to nearly half its bulk. On the average 1·82 oz. of scum were removed for each 100 lbs. of juice boiled and 3·12 oz. of foreign matter were removed by straining the juice before liming for the same quantity of juice. On the whole this amounts to very nearly one and a half pounds of foreign matter, or dirt, removed

Removing of scum.

for every 100 lbs. of jaggory boiled, for it took between four and five pounds of juice to produce one pound of jaggory. Of course if the skimmings are not placed on some suitable filter such as a piece of "long cloth" and the juice, which is inevitably removed when skimming, is not saved, the loss will be very great. On the other hand, if an attempt is made to separate the scum from the juice removed with it by either using, as is generally done, a perforated skimmer, or by putting the skimmings into an ordinary basket and letting that which passes through the meshes of the basket run back into the pan, the greater part of the scum is simply broken up and returned to the juice and the attempt to remove the scum has very little practical result. The filter cloths must of course be carefully washed and dried each time they have been used, and on the score of cleanliness *no* wooden baskets should be used.

TABLE No. II.

Jaggory boiled from juice fully limed.

No.	Substance	How limed	Sucrose	Glucose	Total solids	Weight of juice required for 100 lbs. of jaggory	Glucose formed during boiling	Colour			Remarks
								Lovibond's Tintometer		Empirical	
								Yellow	Red		
1	2	3	4	5	6	7	8	9	10	11	12
281	Juice from Plot I A ...	Fully ...	19·60	0·54	20·9	...	...	...	...	...	
282	Jaggory boiled from 281...	Do ...	91·40	2·30	...	514	0·00	...	...	...	
289	Juice from Plot I C ...	Do ...	19·05	0·59	20·2	...	...	...	...	...	
290	Jaggory from 289 ...	Do ...	87·90	2·99	...	521	0·73	...	...	56	
296	Juice from Plot I E ...	Do ...	18·90	0·48	19·9	...	...	...	...	...	
297	Jaggory from 296 ...	Do ...	82·90	3·78	...	524	1·67	...	...	91	
298	Juice from Plot I E ...	Do ...	19·40	0·57	20·6	...	...	...	...	...	
299	Jaggory from 298 ...	Do ...	85·15	2·80	...	640	0·30	...	...	55	Badly charred.
302	Juice Plot I F ...	Do ...	19·80	0·70	21·1	...	...	...	...	...	
303	Jaggory from 302 ...	Do ...	81·60	4·30	...	528	1·42	15	3·1	102	
309	Juice Plot I H ...	Do ...	19·35	0·65	20·7	...	...	...	..	...	
310	Jaggory from 309 ...	Do ...	84·70	3·50	...	512	0·66	...	..	81	
311	Juice Plot I H ...	Do ...	19·05	1·00	20·8	...	..	...	...	...	
312	Jaggory from 311 ...	Do ...	81·80	5·26	...	...	0·97	...	...	104	
313	Juice (Cheni) ...	Do ...	15·70	0·96	17·9	...	...	...	...	...	
314	Jaggory from 313 ...	Do ...	71·00	11·90	..	...	6·56	13·2	2·4	101	
316	Juice mixed lot ...	Do ...	17·60	1·80	20·6	...	...	...	...	...	Some of the canes had been lying for three days before milling.

TABLE No. II—*concld.*

No.	Substance	How limed	Sucrose	Glucose	Total solids	Weight of juice required for 100 lbs. of jaggory	Glucose formed during boiling	Colour			Remarks
								Lovibond's Tintometer		Empirical	
								Yellow	Red		
1	2	3	4	5	6	7	8	9	10	11	12
317	Jaggory from 316 ...	Fully ...	75·80	8·47	...	...	3·36	27	7·5	38	Charred.
318	Juice Plot II B ...	Do ..	18·40	0·67	19·8	...	...	...	...	..	
321	Jaggory from 318 ...	Do ...	83·40	3·70	...	...	0·66	22	5·1	69	
322	Juice Plot II B ...	Do ...	19·05	0·80	20·4	...	...	...	...	...	
323	Jaggory from 322 ...	Do ...	81·75	6·30	..	...	2·87	...	...	92	
399	Juice Plot II G ...	Do ...	15·50	1·02	17·4	...	...	...	...	...	No. 399 and following cut three months later than the others.
400	Jaggory from 399 ...	Do ...	79·00	6·85		...	1·65	...	...	...	
401	Juice Plot III A and B ...	Do ...	15·47	0·99	17·5	...	..	...	...	...	
402	Jaggory from 401 ...	Do ..	77·45	8·47	..	...	3·52	17	3·7	95	
403	Juice from Plot III C and D	Do ...	15·80	0·82	17·9	...	...	...	...	...	
404	Jaggory from 403 ...	Do ...	81·90	4·80	...	..	0·55	22	5·4	58	
405	Juice from Plot III E and F	Do ...	15·50	0·88	17·1	...	...	...	...	..	
406	Jaggory from 405 ...	Do ...	76·40	9·30	...	...	4·96	13	3·1	100	
332	Juice from Plot II D ...	Overlimed	18·10	0·73	19·0	...	...	..	...	...	
335	Jaggory from 332 ...	Do ...	85·30	3·70	...	...	0·26	...	...	60	
336	Juice Plot II D ...	Do ...	17·35	0·86	18·6	..	...	...	...	...	
337	Jaggory from 336 ...	Do ...	81·80	3·80	...	...	0·00	...	...	46	

TABLE No. III.

Jaggory boiled from juice partially limed.

No.	Substance	How limed	Sucrose	Glucose	Total solids	Weight of juice required for 100 lbs. of jaggory	Glucose formed during boiling	Colour			Remarks
								Lovibond's Tintometer		Empirical	
								Yellow	Red		
1	2	3	4	5	6	7	8	9	10	11	12
287	Juice (mixed lot) ...	Three-quarters	19·40	0·79	20·7	...	...	...	...	...	
288	Jaggory from 287 ...	Do ...	82·80	4·27	...	494	1·10	...	...	70	
294	Juice (mixed lot) ...	Do ...	18·20	0·77	20·6	...	...	...	...	...	
295	Jaggory from 294 ...	Do ...	81·30	5·80	...	534	2·36	...	...	91	
300	Juice Plot I E ...	Do ...	19·50	0·88	21·0	...	...	...	...		
301	Jaggory from 300 ...	Do ...	83·10	3·90	...	491	0·15	...	...	70	
304	Juice (mixed lot) ...	Do ...	19·50	0·69	20·9	...	...	...	...	...	
305	Jaggory from 304 ...	Do ...	82·65	4·80	...	547	1·88	...	...	65	
407	Juice from Plot III G & H	Do ...	16·15	0·90	18·5	...	...	...	...	...	
408	Jaggory from 407 ...	Do ...	80·50	5·40	...	...	0·92	...	...	...	
409	Juice from Plots I & J ...	Do ...	16·05	0·95	18·1	...	...	...	...	...	
410	Jaggory from 409 ...	Do ...	77·45	8·70	...	...	4·12	19	3·9	70	
283	Juice from Plot I B ...	Half-limed ...	19·80	0·60	21·0	...	...	...	...	...	
284	Jaggory from 283 ...	Do ...	85·50	4·03	...	484	1·44	...	...	72	
307	Juice from Plot I G ...	Do ...	18·30	0·90	20·1	...	...	...	...	...	
308	Jaggory from 307 ...	Do ...	78·90	6·49	...	551	2·61	...	...	70	
292	Juice from Plot I D ...	Quarter-limed	18·50	0·62	19·6	...	...	...	..	...	
293	Jaggory from 292 ...	Do ...	80·90	6·80	...	400	4·09	...	...	103	

NOTE.—(1) 25 Grams of jaggory dissolved in 500 C. C. of water. The figures in column 10 indicate the depth in millimetres of columns of these solutions having the same colour. NOTE.—(2) The shade of colour was determined in a 2' cell.

38. *Glucose in juice.*—The glucose in the juice is higher than was expected when starting the milling of the cane. For as sample No. 280, taken before milling began, contained less than half per cent, it was hoped that, as time went on, the glucose would drop still lower than that figure, as it actually did in some cases, but the average is decidedly above half per cent. Why this is the case requires further inquiry. It may be that the canes were not milled as soon as should have been done after being cut. It may be that canes which had been killed by white ants but still looked fresh were not carefully enough excluded, or it may be due to some other unknown or unsuspected cause.

39. *Glucose formed during boiling.*—The amount of glucose formed during boiling is also peculiar and inexplicable at present. When leaving out samples Nos. 399 and those following it which (as they were over-ripe, as considerable glucose formed during boiling and as they were nearly all fully limed) it would not be right to include, and No. 314 which is also evidently abnormal, the average per cent of glucose formed during boiling in the samples fully limed was 1·17%. In the three-quarter limed samples 1·37% of glucose was formed in this way, and in the half-limed sample and quarter-limed samples 2·02% and 4·09%, respectively, of glucose were formed in this way. But as the amount of glucose formed during boiling varied in the fully limed samples from nothing to 3·36%, it is evident that some other causes than the extent of liming were at work and that these figures do not indicate simply differences due to liming. The sample in which 3·36% of glucose was formed during boiling was badly charred; but as in the only other sample which was badly charred only 0·3% of glucose was formed in this way, the charring cannot be the only or chief cause of this glucose formation. If the fact that part of the cane used for this jaggory No. 317 had been cut three days before being milled had anything to do with this abnormal glucose formation, I cannot say. But I shall make experiments in that direction as soon as circumstances permit.

40. *Colour.*—In order to be able to give a numerical value to the depth of colour of the various jaggories, it was

decided to dissolve 50 grams (nearly 4½ tolas) of the jaggory in one liter (a little less than a quart) of water. These solutions were filtered to remove all suspended matter and filled into glass tubes to such a height that the colours in all the tubes were of the same depth. The lighter the colour of the jaggory the thicker of course the layer of this solution had to be to match the depth of the colour of the other solutions of jaggory. The thickness of these layers or the height to which these tubes had to be filled to match each other in colours, were measured and are given in column No. 11 in the Tables No. II and No. III above. The higher this number the lighter the colour of jaggory. A popular belief is that jaggories produced from juices which are "heavily" limed are darker, in proportion to the amount of lime added to the juice, than jaggories boiled from juice to which less lime has been added. When studying this problem we must exclude jaggories Nos. 299 and 317 as these were badly charred when boiled and had therefore a much darker colour than would be due to the lime added to the juice. Possibly some of the other samples of jaggory were also slightly charred, and this may account for the comparatively great variations which exist between jaggories apparently treated alike; but if any of the others have been charred, it was not enough to be easily detected. The average of the depth of colours of the jaggories "fully" limed is 81, and leaving out sample No. 314 which was very light in colour but which behaved peculiarly as far as the glucose is concerned, the average is still very nearly 80. The average of the three-quarter limed jaggory is 61 and the half-limed lot had an average of 71. The "fully" and "overlimed" jaggories (for the significance of these terms refer to page 9) were therefore those having the lightest colour, while those limed nearly but not quite to neutrality (the three-quarter limed lot) were the darkest and the half-limed lots were intermediate to the other two. The quarter-limed jaggory is left out of consideration as there was only one of these. These figures confirm last year's impressions as given in para 24, page 8, of the 5th Annual Report of this Department. The colour of the jaggory appears to behave very much in the same way as the colour of the juice

of sugar-cane. The more lime is added to this the darker it gets until it is fully neutralized and becomes alkaline in reaction when the colour becomes very much lighter than it was before reaching neutrality. The raiyats who do not lime their juice *sufficiently* are therefore right in their opinion that the jaggory becomes darker in colour the more lime is added. *But if they add all the lime which is really required, the jaggory will have a brighter colour than that which is now produced*, and in addition it will be of much better quality. *That is, if the experiments made in the Laboratory compound, which has a very light red coloured soil, apply to the State as a whole*, and I have no reason to believe that they do not do so.

41. In columns 9 and 10 of table on p. 18 are given the results obtained with the Lovibond Tintometer on the solutions mentioned above, *viz.*, 50 grams in one liter. A two-inch cell was used. But these figures, though very valuable in giving a permanent record of the actual colours, are not of much interest except to those using this particular instrument. And as every one using that instrument will understand them without further explanation, no further comments are needed.

SUGARS.

42. A large and greatly increasing quantity of sugar is being imported to India every year. In 1893-94 this quantity was a little over 106,000 tons. Five years later the import had nearly doubled, being nearly 204,000 tons; and last year it was a little over 290,000 tons, which is an increase of over 42% in these last five years. This import amounts to nearly 2 lbs. per head of population, and must represent a very considerable part of the total sugar consumption of India. These imports now come chiefly from Mauritius and Java, and less than 27,000 tons came last year from beet-sugar-producing countries. That such a large and increasing import of sugar takes place shows conclusively that there is something radically wrong with the Indian sugar industry. As far as Mysore is concerned, this "something" is certainly not to be found in the

quality of the cane. For I know of no other country in the world in which sugar-cane is grown which contains 20 and 21% of sucrose as it does in Mysore at times. The quantity of cane per acre should of course be improved. But probably there is no part of the industry which requires greater improvement than the manufacturing side. The milling of the cane, the liming, the removal of scum when boiling and the guarding against loss from fermentation of the juice are factors which require careful attention. But as the sugar imported is either refined or goes to the Indian refineries to be refined before being placed on the retail market, it is evident that in order to compete with this imported sugar we must treat our cane juice in such a way as to produce in the most economic way high grades of sugar. And we are unable to do this as long as we produce jaggory first and send that to the factories to be refined. The fuel used to boil down the juice to jaggory is practically wasted, and the char filters and other parts of the refineries are given infinitely more work than need be if the molasses is not removed from the sugar before the latter is refined. Moreover the best grades of raw, centrifugalled sugar manufactured in the districts could be of a sufficiently high quality to be able to replace directly a part of the imported sugar. Jaggory would be unable to do this. As the universal experience is that refined sugars gradually replace the lower grades of sugars in the market, it is self-evident that as long as jaggory continues to be the chief product of the sugar-cane, the sugar industry is bound to decline unless a jaggory can be manufactured which is eminently suited for refining purposes. And as, for the reasons given above, this is not likely to be the case, it is necessary to replace jaggory boiling by more modern methods and to produce as good a quality of raw sugar as the circumstances will permit if the imported sugar is to be replaced in the Indian market by that produced in the country. India is the home of the sugar industry, and when sugar was first imported into Europe it was known by the name of "Indian salt." But the methods which were eminently successful 700 years, or even 150 years ago, cannot compete with modern applicances in an industry in

which such advancement has been made as in sugar boiling. Sugar has dropped very much in price. When first imported in large quantities into Europe it was sold for a price considerably over Re. 1 per pound. In fact only about 100 years ago it was sold, for a short time, for well over Rs. 2 per pound on the continent of Europe; but this excessively high price was due to great restrictions having been placed on trade with sugar in continental Europe. The present comparatively very low price is in a great measure due to better and cheaper methods of production, and in order to compete even in our own markets with countries employing these cheaper and better methods of productions, we must improve our own methods. If their methods are not applicable here we must make our own improvements but improvements we must make if we want to keep a sugar industry. It is with a view of finding in how far we can adopt some of the improvements made elsewhere, without completely upsetting our existing industry, that the following experiments were made:—

43. The juice was treated exactly as described under the head of jaggory-boiling, but the boiling was not carried on quite as far, being stopped when the condensed juice on cooling formed a mass of about the consistency of thick mud. Experience alone can tell when the boiling has been carried on far enough, but a good jaggory-boiler will very soon learn this. We had not the slightest trouble in this respect. This mass called massecuite was allowed to stand for three or four days, or longer if more convenient to do so. It was then thoroughly mixed, all hard lumps broken up and put into a small centrifugal in which the molasses was separated from the sugar. In the table below are given the composition of the juice and the massecuite, and the sugar and molasses separated from it. The molasses was boiled a second time, and the amount of so-called second sugars separated from this molasses is also given.

TABLE

Serial No.	Substance	Weight of water (lbs.) used per 100 lbs. of sugar for washing in centrifugal	Percentage of sucrose	Percentage of glucose	Percentage of total solids
1	2	3	4	5	6
306	Juice from Plot I G ...	.....	19·55	0·91	21·3
378	Massecuite boiled from above 306	.....	74·85	6·30	...
379	(*a*) Sugar made from 378	Unwashed	95·60	1·20	...
380	(*a*) Molasses separated from 379	.....	49·70	12·80	...
381	(*b*) Sugar do ... 378	Unwashed	94·00	1·50	...
382	(*c*) Molasses do ... 381	.....	49·60	12·80	...
383	(*d*) Sugar do ... 378	Unwashed	94·70	1·30	...
384	(*e*) Do do ... 378	5·12	97·50	0·68	...
324	Juice from Plot II C ...	.....	18·10	0·80	19·6
385	Massecuite boiled from ... 324	.....	78·20	4·46	...
387	(*a*) Sugar separated from 385	4·45	95·00	1·00	...
388	(*b*) Do 385	Unwashed	94·40	1·32	...
391	(*c*) Do 385	4·61	95·90	1·12	...
329	Juice from Plot II C ...	.....	18·00	1·16	19·9
389	Massecuite boiled from ... 329	.....	76·90	6·25	...
390	(*a*) Sugar separated from 389	Unwashed	95·20	1·57	...
392	(*b*) Do 389	Do	94·90	1·74	...
331	Juice from Plot II C ...	.. ...	17·40	0·86	18·9
370	(*a*) Massecuite b'ld. frm. 331	.....	80·25	4·63	...
371	Sugar separated from ... 370	7·48	98·10	0·45	...
372	Do 370	7·48	98·50	0·40	...

No. IV—*Sugars.*

Moisture	Percentage of first sugars calculated on first massecuite	Percentage of first sugars calculated on first massecuite before being washed	Percentage of second sugars calculated on weight of first massecuite	Percentage of total sugar calculated on weight of first massecuite	Pounds of centrifugalled sugar obtained from weight of juice giving 100 lbs. jaggory	Colour			Remarks	Serial No.
						Lovibond's Tintometer		Empirical		
						Yellow	Red			
7	8	9	10	11	12	13	14	15	16	17
...	...	...	...	...	...	...	...	...		306
...	...	...	...	...	...	...	...	...		378
1·99	60·1	...	17·1	77·2	82·5	18	3·3	80		379
...	...	...	...	...	...	...	...	...		380
3·06	62·0	...	16·3	78·3	83·7	18	4·3	75	Beltbroke.	381
...	...	...	...	...	...	...	...	...		382
2·08	61·8	...	16·4	78·2	83·6	18	3·7	72		383
1·80	58·6	64·02	17·8	76·4	81·7	7	1·8	152		384
...	...	...	...	...	...	...	...	...		324
...	...	...	...	...	...	...	...	...		385
2·88	62·53	67·3	16·1	78·63	83·8	25	5·1	55		387
2·66	66·37	...	14·4	80·77	86·4	60	7·7	35		388
2·30	63·68	69·7	15·6	79·28	...	24	4·4	45		391
...	...	...	...	...	...	...	...	...		329
...	...	...	...	...	...	...	...	...		389
1·90	61·97	...	16·3	78·27	84·7	18	4·5	65		390
1·50	64·60	...	15·2	79·8	85·6	67	6·0	42		392
...	...	...	...	...	...	...	...	...		331
...	...	...	...	...	...	...	...	...		370
·26	56·8	58·0	18·5	75·3	80·5	18	3·7	80	Coarse.	371
...	56·8	...	18·5	75·3	80·5	14	3·2	87	Fine.	372

TABLE

Serial No.	Substance	Weight of water (lbs.) used per 100 lbs. of sugar for washing in centrifugal	Percentage of sucrose	Percentage of glucose	Percentage of total solids
1	2	3	4	5	6
373	(*b*) Massecuite b'ld frm. 331	.....	81·20	4·46	...
374	Sugar separated from ... 373	Unwashed	97·40	0·80	...
375	Do do 373	Do	97·10	1·00	...
376	Molasses do 375	.....	53·50	10·20	...
377	Sugar do 373	2·31	98·00	0·80	...
393	Sugar separated out of a mixture of all the molasses on standing	.....	86·00	4·06	...
397	Juice from Plot II F ...	.....	15·50	1·08	17·7
398	Massecuite boiled from ... 397	.....	73·35	9·40	...
459	Sugar separated from ... 398	Unwashed	96·50	3·70	...
461	Molasses do ... 459	.....	46·50	18·50	...
460	Sugar do ... 398	Unwashed	89·95	3·70	...
462	Molasses do ... 460	.....	45·10	20·30	...
394	Molasses out of which 393 was separated	.....	53·75	12·50	...
452	Massecuite b'ld from 394 (2)	.....	59·50	13·50	...
453	Sugar separated out of ... 452	Unwashed	86·50	5·1	...
456	Molasses separated from 453	.....	32·30	27·7	...
454	Sugar separated out of ... 452	Unwashed	87·00	5·2	...
457	Molasses separated from 455	.....	31·70	27·7	...
455	Sugar separated out of ... 452	Unwashed	85·90	5·3	...
	Average of all jaggories in the next table	.....	81·63	5·48	...
	Average of sugars in this table	.....	95·80	1·39	...

Note—(1) Calculated on amount of molasses.
(2) 100 lbs.of molasses gave 87·7 lbs. of massecuite.

No. IV—*concld.*

Moisture	Percentage of first sugars calculated on first massecuite	Percentage of first sugars calculated on first massecuite before being washed	Percentage of second sugars calculated on weight of first massecuite	Percentage of total sugar calculated on weight of first massecuite	Pounds of centrifugalled sugar obtained from weight of juice giving 100 lbs. jaggory	Colour			Remarks	Serial No.
						Lovibond's Tintometer		Empirical		
						Yellow	Red			
7	8	9	10	11	12	13	14	15	16	17
...	...	...	...	...	...	...	...	...		373
·43	...	...	...	...	...	25	5·7	50	Coarse.	374
·49	86·00	...	13·7	81·7	87·3	25	5·9	50	Fine.	375
...	...	...	...	...	...	...	...	...		376
·35	63·5 (1)	68·87	15·7	79·2	84·6	20	4·6	63		377
...	4·02	...	...	...	...	...	...	...		393
...	...	...	...	...	...	...	...	...		397
...	...	...	...	...	...	...	...	...		398
...	62·3	...	16·2	78·5	83·9	73	11	34		459
...	...	...	...	...	...	...	...	...		461
...	63·3	...	15·7	79·0	84·4	74	11	32		460
...	...	...	...	...	...	...	...	...		462
...	...	...	...	...	...	...	...	...		394
...	...	...	...	...	...	...	...	...		452
...	...	...	46·9	...	...	168	24	8		453
...	...	...	...	...	...	...	...	...		456
...	...	...	47·4	...	...	112	24	8½		454
...	...	...	...	...	...	...	...	...		457
...	...	...	50·5	...	...	124	26	8		455
...	...	...	...	...	...	...	...	...		
...	62·16	...	...	...	83·78	...	...	...		

44. *Centrifugal.*—Last year a regular sugar centrifugal 18 inches in diameter, geared by means of cog-wheels to a speed which was supposed sufficient for hand use was used to separate the molasses from the massecuite and produce centrifugal sugar. But the centrifugal was so difficult to turn at a speed approaching that required for sugar work that all attempts to use it proved a failure. This year an American laboratory hand-centrifugal with a 10-inch basket geared so that it could be run at a speed of about 1,500 revolutions was used. The maximum amount of massecuite which could be centrifugalled at one time was about 11 pounds, which gave roughly speaking about 7 pounds of sugar. But the work required to separate this small amount of sugar was so great that only a comparatively small quantity of the juice was boiled into massecuite, the greater part being used for jaggory. This was no doubt partly due to the fact that the centrifugal was not specially made for sugar work. But our experiments so far give little hope that hand centrifugals can be used to advantage in the production of sugar for the market. But the quality of sugar produced and its outturn when compared with jaggory as given in column No. 12 of the above table are very encouraging indeed, and make it highly desirable to repeat these experiments as soon as possible with a larger plant driven by steam, or an oil-engine where fuel is very difficult to get.

45. The best sample of sugar given in the above table is No. 372. It is an extraordinary fine sample of raw centrifugal sugar and it received no special treatment except that it was washed in the centrifugal with about $7\frac{1}{2}$ per cent of its own weight of water. In other words after all the molasses which could be easily separated by this small centrifugal had been got rid of, a little water was poured into the centrifugal when in motion and this in passing through the sugar removed the greater part of the remaining molasses. After this washing it was allowed to dry six or seven hours, and after that passed through a sieve to separate the larger grains from the smaller ones. This was done to give the sample a more uniform appearance.

It was one of the samples sent to the Bellary Exhibition. In this sample there was less than a half per cent of glucose. Sample No. 371 representing the portion which remained on the sieve when preparing the sample No. 372, is of very nearly the same composition though a little darker in colour. But judging from the results of this year's work it is doubtful if the washing of raw sugars in the centrifugal pays.

46. The molasses separated from all the various samples of sugar was mixed together. After standing for over a month, some very fine-grained sugar separated out. This was removed by passing all the molasses through the centrifugal. The sugar obtained in this way is sample No. 393, which contains, as will be seen, a high percentage of glucose, and is somewhat similar to samples Nos. 452-454. The latter are so-called second sugars, that is, they were obtained as stated above by boiling down the molasses a little further and allowing it to stand for several weeks to permit the sugar to crystallise out of the tarry mass. The quantity of molasses was rather too small to permit of easy boiling. The entire mass charred for some unknown reason, and the second sugars produced were very dark on that account. 64¾ lbs. of molasses were boiled down to 52¼ lbs. second massecuite, in other words, only 19·3 per cent of water were evaporated. On an average 10 lbs. of second massecuite gave 4·83 lbs. of the second sugars. Or nearly 39 per cent of the original molasses was transformed into second sugars. When we add to this the 4 per cent of sugar separated out of the molasses on standing, we find that every 100 lbs. of the original molasses gave 43 lbs. of sugar. This figure forms the basis for calculating the quantity of second sugars entered in column No. 10. The figures in column No. 12 indicate the amount of centrifugal sugars (first and seconds combined) which were obtained from a quantity of juice which would have given 100 lbs. of jaggory of the average composition of the jaggories produced this year, the analyses of which are given in Tables No II and No. III. The remainder has been separated out in the form of molasses. This, as will be seen by referring

to No. 456 and No. 457 in the table above, has 27·7 per cent of glucose and only 32 per cent of cane-sugar. This is a very satisfactory result as it shows that but little more cane-sugar has passed into the molasses than the glucose contained in it. This is especially satisfactory for a first attempt. But it is to be hoped that the amount of glucose formed during boiling will be materially reduced in future experiments. This hope is justified by the results of the experiments of previous years. On the whole we have every reason to hope that with a comparatively small expenditure in machinery we will be able to very materially improve the sugar industry of Mysore. Whether it will be advisable or necessary to use pans heated by steam instead of by direct firing, future experiments will have to show.

47. *Milling of cane.*—It is of course in the juice of the sugar-cane in which the cane-sugar (the substance for which the sugar-cane is cultivated) is found. The solid structures which form the vessels containing the juice are of comparatively little if any commercial value, but are generally used as fuel for boiling down the juice. It is however practically impossible to completely separate the juice from the solid structure called mark. Even the best mills leave a small proportion of the juice with the mark. This mixture of mark and juice left in it after milling is called begasse, or in some countries meggasse. Begasse from the most powerful nine-roller mills still contains about 5 per cent or a little more of the juice. The proportion of the juice left in the begasse is of course less when the mills are large and the pressure great. But in addition to the greater pressure which can be exerted by large mills, these large nine-roller mills have the additional advantage that the cane is sprinkled with water between each set of three rollers. The juice being diluted in this way, the portion left in the cane is also diluted and contains less sugar than it otherwise would. The begasse is similar to a sponge soaked in juice of sugar-cane and squeezed dry. The harder it is squeezed the larger the proportion of the juice which will run out. If it is afterwards soaked in water and again squeezed to the same extent, more diluted

juice runs out; and if this process is repeated often enough, the sponge will finally be practically free of juice. By this method of sprinkling the cane with water as it passes from one set of rollers to the other much more juice can of course be extracted than without it. But in addition to the size and construction of the mill, the amount of mark the cane contains will materially affect the amount of the juice lost in the begasse. A small sponge will retain a much smaller weight of liquid (or juice) than a larger sponge subjected to the same pressure. Sugar-cane containing little mark is, therefore, other things being equal, more valuable than cane containing much mark; and this must be taken into account when judging the efficiency of a sugar-cane mill.

TABLE No. V.

Showing percentage of juice left in begasse (refuse cane) when milling with ordinary three-roller iron sugar mill.

Serial No. of juice	Weight of cane used, lbs.	Weight of juice obtained, lbs.	(1) Percentage of extraction	(2) Weight of begasse, lbs.	(3) Percentage of extraction	Total solids in juice	Moisture in begasse	Percentage of mark (4) in begasse	Percentage of juice left in begasse
1	2	3	4	5	6	7	8	9	10
281	343¾	200½	58·0	137½	602	20·9	59·06	10·08	31·9
283	414¼	252	60·8	148	64·3	21·0	56·51	10·17	28·4
285	431	259½	60·0	162½	62·3	21·0	56·89	10·35	30·3
289	451	276½	61·3	166	63·2	20·2	56·70	10·66	29·3
291	472	289½	61·3	170	64·0	20·0	59·59	9·18	29·5
292 (5)	450½	224	47·7	215	52·3	19·6	55·65	14·69	38·7
294	413¼	283½	68·6	120	71·0	20·6	55·80	8·62	22·3
296	406	262½	64·5	137½	66·2	19·9	59·55	8·69	28·5
298	178	128	71·9	46¼	74·1	20·6	57·41	7·17	20·2
300	467¾	284½	60·8	179¾	61·6	21·1	51·61	13·28	29·0
302	428½	280	65·3	141	67·1	21·1	56·73	9·24	26·1
304	454	284¾	62·3	162¼	64·5	20·9	51·26	12·50	26·3
306	473	314½	86·4	149½	68·4	21·3	53·75	10·02	24·0

TABLE No. V—*concld.*

Serial No. of juice	Weight of cane used, lbs.	Weight of juice obtained, lbs.	Percentage of extraction (1)	Weight of begasse, lbs. (2)	Percentage of extraction (3)	Total solids in juice	Moisture in begasse	Percentage of mark (4) in begasse	Percentage of juice left in begasse
1	2	3	4	5	6	7	8	9	10
307	472	311½	66·0	151¾	67·8	20·1	55·50	9·82	24·8
309	370½	251	67·7	111½	70·0	20·7	57·63	8·20	23·7
311	433¾	285	65·7	139	68·0	20·8	53·86	10·24	24·2
(6)									
313	494	282½	57·2	200½	59·4	17·9	47·64	17·04	28·4
316	379½	253½	66·8	117½	69·0	20·6	51·40	10·93	22·5
318	377¾	253¾	67·1	118	78·8	19·8	56·94	9·06	24·4
322	353	225	63·7	120	66·0	20·4	52·59	11·54	25·4
324	386	269½	69·2	118	69·4	19·6	53·75	10·15	22·8
329	431¾	283½	65·6	136	68·5	19·9	52·04	11·04	23·0
331	454	298½	65·7	148	67·4	18·9	52·30	11·56	23·7
332	416½	266	63·9	137½	67·0	19·0	53·95	11·02	24·7
336	469½	314	66·8	138	7·06	18·6	53·71	10·00	21·6
(7)									
395	479	314	65·5	153½	67·9	17·0	60·90	8·55	25·8
(7)									
397	446	286	64·1	147½	66·9	17·7	59·8	9·04	26·4
(7)									
399	484	318	65·7	152	68·6	17·4	58·5	8·75	24·8
(7)									
401	510	328	64·3	172½	66·2	17·5	60·3	8·75	27·4
(7)									
403	529	342	64·6	173	67·3	17·9	60·5	8·60	26·4
(7)									
405	418	274	65·5	128	69·4	17·1	58·2	9·12	23·6
(7)									
407	408	269	95·9	131	67·9	18·5	62·0	7·68	26·8
(7)									
409	537	340	63·3	189	64·8	15·1	59·3	9·71	28·2

(1) Extraction calculated by dividing the weight of juice by the weight of cane.
(2) Begasse is the refuse cane coming out of the mill.
(3) Extraction calculated by dividing the weight of begasse by the weight of cane. This is not as accurate as the extraction given in column 4 as the begasse loses weight very rapidly owing to the large surface from which the juice can evaporate.
(4) Mark is what remains when *all* the juice is removed from the sugar-cane.
(5) The cane from which juice No. 292 was obtained was very short in the joints. This accounts for the high percentage of mark and the low extraction.
(6) The cane from which the juice No. 313 was obtained was a hard thin variety known as Chinikabbu.
(7) The begasses corresponding with the sample of juice No. 395 and succeeding samples were sampled, weighed, and dried more rapidly than the others, and the figures given in the columns 9 and 10 for these samples are therefore more accurate than the others in the same columns.

48. The mill used in the experiments this year was a locally made three-roller iron mill. The rollers are placed vertically and are of equal size— 9 inches long and 6½ inches in diameter. The figures given in column 4 and column 6 ought to be the same if both were absolutely accurate. But the refuse cane or begasse loses weight very quickly owing to the juice still retained in it evaporating very quickly, for it is spread out in a thin layer over a large surface. As the begasse is really heavier immediately after it is milled than a little later when it is actually weighed, the results calculated from the figures thus obtained give a little higher extraction than that which is actually obtained. But the juice in the pails also evaporates a little before weighing, though not nearly as much, as that in the begasse; the results obtained when dividing the weight of the cane into the weight of the juice as given in column 4 are therefore not quite accurate either. They are a little too low. The truth is somewhere between these two results though nearer those given in column No. 4 than those recorded in column No. 6 in Table No. V above. Nevertheless the latter results are taken for calculating the results given in column No. 10, and these results are therefore too low in exactly the same proportion as the figures in column No. 6 are too high. There is therefore actually a little more juice left in the begasse (refuse cane) than these figures indicate. The mill was set much closer than is usually done by the raiyats. (The begasse was very much cut up when it came out of the mill and was in small pieces so that all of it had to be carried in baskets from the mill to the scales.) And the juice left in the begasse in actual practice is therefore more than it was in these experiments. With these small iron mills which are no doubt a great improvement on the old wooden mills, there is therefore a loss of ¼ to ⅓ of the juice originally contained in the cane. This is a loss much greater than was anticipated. For some time to come the best mills, those extracting all but five per cent to ten per cent of the total juice of the cane, are both too large and too expensive to be used in Mysore except by large firms having a large area under sugar-cane; for they can mill from 500 to nearly 1,000 tons of cane a day and could easily mill

1,000 acres of the best cane in a season. But there is a very large range in sizes of sugar-cane mills between these giants, and the so-called improved sugar-cane mill used in Mysore. And with a mill very much smaller and cheaper than the largest mills in use elsewhere a very much better extraction should be possible than the "improved mills" in Mysore are able to give. Next year it is hoped we shall be able to make experiments with a three-roller mill driven by an oil-engine having rollers eighteen inches long by twelve inches in diameter capable of crushing one ton of cane per hour. The rollers lie horizontally. Such a mill is being imported for Mr. Krishnaiengar, Inamdar of Oorgahalli, and experiments will be made with it after it arrives.

49. *Deterioration of cane after cutting.*— The general impression in cane-growing countries appears to be that cane deteriorates but little after being cut for a day or two at any rate. In Louisiana cane is sometimes preserved in pits for a month or more after cutting for seed. Cane sent for some distance to central factories must of course be cut some considerable time before being milled, especially if it is sent, as is sometimes done, for fifty miles or so. And when considering the advisability of starting Central Sugar Houses in India, a very important question is to find out how long cane will keep and how far it may be sent without serious loss. For the purpose of studying this question the canes from one plot were divided as evenly as possible into twenty samples. Of these, two were analysed soon after being cut. But as there appeared no special reason for hurrying and as the sorting and sampling took some time, these samples had been cut for some hours—probably four or five—before being analysed. The other samples were analysed from two days to one month later. Some samples were not topped, to see if this would have any effect on their keeping quality. Below are given the results of the analyses together with the dates on which they were made.

TABLE No VI.

Table showing the effect of cutting cane before milling it. Analysis of juice of sugar-cane cut, April 22nd, 1905, and kept for various lengths of time:—

No.	Date	Weight		Sucrose; per cent	Glucose; per cent	Total solids per cent	Calculated to original weight taking ten per cent mark in cane			Remarks
		Original lbs.	When analysed, lbs.				Sucrose; cent per	Glucose; per cent	Total solids; per cent	
1	2	3	4	5	6	7	8	9	10	11
338	22 IV 05	26	26	16·40	·87	17·70	16·40	·87	17·7	
339	22 IV 05	25¼	25¼	17·30	·87	18·60	17·30	·87	18·6	
340	24 IV 05	26¼	25½	13·75	3·67	18·60	13·16	3·51	17·8	
341	26 IV 05	26½	24¼	14·35	5·20	19·20	12·94	4·69	17·7	
343	28 IV 05	24¾	21¾	13·40	6·25	20·80	11·56	5·39	17·9	
344	28 IV 05	...	...	15·10	5·81	22·50	...	...	...	Tops left on.
345	1 V 05	24	20	13·35	7·30	22·00	10·87	5·94	17·9	
346	1 V 05	24¾	20½	13·35	7·10	21·70	10·83	5·76	17·6	
347	3 V 05	23	18¼	13·70	7·60	22·20	10·58	5·87	17·1	
348	5 V 05	26	22	13·45	8·50	22·70	11·15	7·05	18·8	
350	7 V 05	21	15½	13·90	8·60	23·80	9·90	6·10	16·9	
351	7 V 05	24	18¼	13·35	8·80	23·70	10·07	6·64	17·9	
352	9 V 05	26½	20	14·70	8·80	24·10	10·70	6·41	17·5	
353	12 V 05	22½	17	12·70	9·40	24·20	9·26	6·85	17·6	
354	12 V 05	26½	19¼	14·15	9·20	24·80	9·82	6·38	17·2	
355	15 V 05	24½	16¾	12·95	10·87	25·50	8·38	7·03	16·5	
356	17 V 05	24½	16¾	12·25	10·90	25·40	7·93	7·05	16·4	
357	17 V 05	24¾	17	12·70	10·10	23·90	8·30	6·61	15·6	
358	19 V 05	24½	16¾	15·05	10·50	25·40	6·80	6·79	16·4	
359	25 V 05	37½	23½	7·80	12·80	23·70	4·57	7·50	13·8	Tops left on.
360	25 V 05	25½	15½	12·30	11·60	26·60	6·95	6·55	15·0	Do

Samples Nos. 338 and 339 have not quite the same composition though they are similar samples. From data found in the analyses of the succeeding samples No. 338 may be taken to very fairly represent the average composition of all the samples on that date. No. 339 is certainly above the average in sucrose and total solids. But it is especially the glucose which we have to consider in this set of experiments. Both samples contain, as will be seen, ·87 per cent of this constituent. As the samples were not milled immediately after they were cut, it is just possible that some change may already have taken place in them when they were analysed; for ·87 per cent is rather more glucose than it was expected to find. But as in the case of the experiments made to test the keeping qualities of juice, practically no change took place in some of the samples during the first nine hours. It is not likely that much change has taken place in these samples of cane before the analyses were made, for it is natural to assume that cane will keep longer than the juice after it has been extracted. In two days time the change in the cane is however very great. As will be noticed by comparing columns Nos. 3 and 4, there has been some loss in the weight of cane, and the percentage of glucose and the sucrose will, owing to the drying out of the cane, of course appear to be higher than it would have been if the cane had not lost some of its water. But this drying has been allowed for in the results given in columns Nos. 8, 9 and 10. These give, therefore, the actual change which has taken place, for in them the changes produced by the simple drying out of the cane has been eliminated. The change in the first two days has been very much greater than in any of the succeeding two days. Why this should be the case is at present difficult to understand. There is an increase of nearly three per cent in the glucose and a decrease of a similar amount in the sucrose. This denotes a very serious loss indeed, as it will probably represent the loss of over one-third of the total sugar if the product is to be sugar and not jaggory. But of course these experiments will have to be repeated a number of times before they can be taken to represent the actual state of affairs. During the first twenty days or more after cutting, the loss in

sucrose was about balanced by the gain in glucose, so that the total solids remained very nearly the same for this period of time. After that the total solids begin to decline, showing that other changes than the simple transformation of sucrose into glucose had taken place. Leaving the tops on the cane has apparently not made much difference in these experiments. But that part of the question has not received a fair test this year. The results of these experiments as a whole have indicated that there probably is a very much greater loss by cutting the canes a day or more before milling than is generally believed. The experiments must be repeated as soon as possible, and the time allowed to lapse between the first four of five analyses must be very much shorter than was the case this time.

50. *Deterioration of juice on keeping.*—When visiting the Refinery at Samalkot in January last, I was asked if in my opinion it would be safe to ship carefully limed juice in properly sterilized iron drums for some distance to the factory. As this question is one of general interest, the following experiments were made to test this point. Juice which was protected as carefully as is possible in ordinary milling practice from being infected with ferments was, after being analysed, set aside in clean glass vessels. Half of it remained unlimed, the other was limed as described in para 34 on page 9 of this report. After a specified time both samples were analysed again. The results are given in the following table :—

TABLE No. VII.

Table showing the amount of fermentation of cane juice, as indicated by an increase in the percentage of glucose, on standing.

No. of juice	Treatment	Analysed after standing hrs.	Glucose per cent	Date of analysis
318	Unlimed ...	Fresh	·67	April 18
	Do ...	7	·82	Do
	Limed ...	7	·75	Do
324	Unlimed ...	Fresh	80	Do
	Do ...	6	·91	Do
	Do ...	20	2·9	Do 19

TABLE No VII—*concld.*

No. of juice	Treatment	Analysed after standing hrs.	Glucose per cent	Date of analysis
	Limed ...	6	·83	April 18
	Do ...	20	6·2	Do 19
332	Unlimed ...	Fresh	·73	Do 20
	Do ...	6	1·10	Do
	Limed ...	6	·74	Do
458	Unlimed ...	Fresh	·61	Do 26
	Do ...	14	2·04	Do 27
	Do ...	19	3·03	Do
	Limed to neutrality	14	1·93	Do
	Do ...	19	3·50	Do
	Over-limed ...	14	·99	Do
	Do ...	19	3·00	Do

51. Taking these results as a whole, there appears to be a slight tendency on the part of limed samples to keep better than the unlimed juice. But as far as these results go, this preserving action is not sufficient to justify any one to rely on it in helping to prevent the juice from fermentation. Further experiments in this direction are given in the following table:—

TABLE No. VIII.

No. of juice	How treated	Fresh juice; glucose per cent	Analysed after standing						Date
			Three hours; glucose per cent	Six hours; glucose per cent	Nine hours; glucose per cent	Thirteen and one-fourth hours; glucose per cent	Seventeen and one-fourth hours; glucose per cent	Nineteen and three-fourth hours; glucose per cent	
452	Unlimed ...	·54	·56	·61	·61	...	...	...	April 26
453	Limed to neutrality	·54	·54	·58	·61	...	...	...	Do
454	Over-limed ...	·54	·54	·56	·61	...	...	...	Do
455	Unlimed ...	·37	...	...	...	·42	·62	1·00	May 8 & 9
456	Limed to neutrality	·37	...	...	...	·40	·57	·80	Do
457	Over-limed ...	·37	...	...	...	·37	·44	·61	Do

In these experiments it was desired to follow the changes taking place in the juice for the best part of a day. To the unlimed and limed samples were added a third into which more than double the amount of lime used for the ordinary "limed" sample had been put. This is described as "over-limed." The first set of three samples were milled one morning and analysed every three hours. The next set of three samples Nos. 455, 456 and 457 were milled in the evening, analysed immediately and allowed to stand overnight. They were analysed again next morning after standing 13¼ hours, 17¼ hours and 19¾ hours. The results show a tendency for the over-limed sample to keep better than the others. But in none of the cases has fermentation been entirely stopped for even twenty hours, and it is doubtful if as satisfactory results as this could be got on an average in general practice. But the experiments are sufficiently encouraging to justify their being continued.

52. *Resume.*—On the whole this year's experiments with sugar-cane and with its manufacture indicate that there is a danger in sending sugar-cane or its juice for distances requiring more than a few hours in transit. The results when making raw centrifugal sugar are so encouraging that it appears likely that even comparatively small houses are likely to help the sugar industry very much.

53. Regarding the opinion that jaggory gets darker in colour the heavier the juice is limed, the experiments show that when the juice is *insufficiently* limed the jaggory gets darker with the addition of lime, but that a sufficiently limed sample of juice gives a jaggory lighter in colour than one from juice limed to one-half this extent. The following directions given last year deserve repetition.

"When boiling jaggory, the greatest care should be taken—

(1) to lime the juice to neutrality as indicated by litmus paper,

(2) to use no earthenware pots,

(3) to wash the mill and all (metal) pots and vessels at least once a day *before* stopping work,

(4) to boil the juice as soon after it is milled as possible,

(5) to see that the rollers of the mill are set as close together as possible," and, added to this,

(6) mill the cane as soon after cutting as possible.

Coffee.

54. *Analyses.*—On page 10 of the Fourth Annual Report are given the results of the analyses of six samples of coffee in which it appears that in a general way the price paid for the coffee decreased with the specific gravity, the nitrogen, phosphoric acid and the potash. On page 11 is stated, "So far as the results go they are very satisfactory indeed. But the number of analyses is much too limited for drawing any conclusions." In the Fifth Annual Report, pages 17 to 24, the continuation of that work has been reported. Fifty-one widely different samples collected by the United Planters' Association of Southern India were tested in regard to their specific gravities. These results bear out the results obtained with the specific gravities the previous year. But the further analyses of the samples indicate no relation existing between the price realized in the London market and the contents of either nitrogen or phosphoric acid or potash, and the sentences quoted above from the Fourth Annual Report have proved amply justified. As the analyses are not quite finished, as some further determinations of some of the organic substances of the coffee are to be made if time permits, and as the analyses so far made are not of any immediate practical value in determining the quality of coffee, the detailed results will not be published until the work has advanced further than it has at present. It is sufficient for the present to note that the total nitrogen, total phosphoric acid and total potash are not an index of quality.

55. *Manurial experiments.*—On pages 6 to 9 in the Fourth Annual Report are given the results of plot experiments with manures on coffee. On experimental fields No. 1 and No. 2 the experiments have been continued for another two years with practically the same results. In both fields

an unmanured plot still heads the list when taking the average of all the years the experiments have been going on. Mr. Denne and Mr. Harris who have conducted, very carefully, the experiments referred to above, have kindly consented to continue them. The amount and nature of fertilizers used, the arrangement of the plots and the results obtained up to 1903, are given in the report referred to above; and as the results since 1903 only serve to confirm the previous results, it is not necessary to give them here. They will, however, be published at some future time. The results obtained so far simply indicate that on these plots the manures applied have not acted. It is simply a coincidence that in both cases an unmanured plot has given the best average results. In Mr. Harris's field which contains two unmanured plots the average of the second of these plots is practically the worst. It is fortunate, however, that in all the experiments an unmanured plot heads the list. The results could not have been interpreted nearly as easily if the unmanured plots had given on an average a result which in its turn had been an average, and they might have been absolutely misleading if they had happened to give as persistently the poorest returns as they happen to have given the best. But if these results are taken to indicate that on these particular plots all the manure applied since the experiments were begun have for some at present unknown reason, failed to give any practical results the interpretation is very safe and very conclusive. As these results have been obtained on two fields it is not unreasonable to suppose that there is a chance of a similar thing happening on other fields.

56. But experiments from only two experimental fields even when conducted for five years cannot of course give *conclusive* results. These experiments cannot therefore be taken to show that coffee has been over-manured in the past and do not prove that if these fields had not been manured at all for five years, the results would have been as good as they would have been if they had been very heavily manured. But they *do* indicate that there is still something to learn about the manuring of coffee, and that

our present treatment is not necessarily the most economic, and they state as plainly as they can that any one anxious to save unnecessary expenditure, would do well to join in this line of experiments to see if it is not possible to reduce expenditure in manures. That we cannot indefinitely crop any piece of land without returning to it at least part of the plant food removed by the crop appears reasonable to all of us. But if we consider the comparatively small amount of plant food removed in 5 cwts. of cleaned coffee, the comparatively rich nature of the soil required for coffee, the fact that at Rothamsted a continuous crop of wheat has been grown on one field for considerably over half a century and is still producing a respectable crop, and that the only actual experiments made with manures on coffee (experiments where the crop from each individual manured plot has been weighed and compared with that produced on a similar adjoining plot which has not been manured) have shown no marked result in favor of the manures applied, it is, I believe, time to be serious about manurial experiments with coffee, and make sure that the good results we believe to have noticed after the application of some one or other manure applied are really due to the manure used and not traceable to some other unexpected cause. For if it were possible to reduce expenses without injuring in any way the returns, the sooner we knew it the better. I therefore strongly urge that a large number of manurial experiments be started with coffee and continued for a considerable time. It is waste to apply more manure than necessary, especially manures like poonacs which are not retained very long by the soil. On the other hand it would be suicidal to manure less than required ; and as practice, no matter how long established, does not necessarily prove a point unless accompanied by experiments, we must make all the experiments possible to test, and if possible, improve our practice. It is reasonable to suppose that in the experiments now carried out, the unmanured plot will drop behind some time. But the fact that this "some time" has not yet arrived ought to make every one interested in coffee anxious to determine whether this is simply due to an accident, or local circumstances, or is caused by some generally existing conditions.

FERTILIZERS.

57. In addition to the analyses made this year, the maximum, minimum and average composition of some of the more important fertilizers, as found in this Laboratory during previous years, has been given to enable those interested in the subject to get a clearer idea of the range in composition which may be expected in those fertilizers in this part of India. The fertilizers analysed this year were, with the exception of ashes, principally analysed to enable firms dealing in fertilizers to give a guarantee with their fertilizers as to their composition.

TABLE No. IX.

Poonacs.

No.	Substance	Nitrogen analyses of previous years			Analysis, 1904-05		Location
		Average percentage	Minimum percentage	Maximum percentage	Nitrogen percentage	Phosphoric acid percentage	
	White castor ...	6·53	5·56	8·69	...	...	
55	Do ...	...	...	...	4·76	...	
69	Do ...	...	...	...	6·35	2·62	Bangalore
	Kurdi ...	4·83	3·92	6·43	...	...	
206	Do ...	...	...	...	8·30	...	
207	Do ...	...	...	...	4·86	...	Hubli
	Neem (Melia Azadi) ...	5·01	4·43	5·99	...	...	Do
58	Do ...	...	...	...	4·12	...	
	Honge (Pongamia glabra)	3·81	3·59	4·01	...	...	
70	Do ...	...	...	...	3·88	·99	Bangalore
	Ippe (Bassia latifolia) ...	2·97	1·80	4·14	...	...	

58. *White castor.*—No. 69 is a white castor poonac taken from a large heap, and as might be expected represents fairly well an average sample of good average white castor. The firm in question excluded as far as possible all samples which appeared adulterated. Sample No. 55 is, I believe, also taken from "bulk," but is, as will be noticed, very poor, having a lower percentage of nitrogen than any other sample analysed in this Laboratory before. It came

from outside of Mysore and indicates the necessity of consumers insisting on a guarantee as to composition.

59. *Kurdi.*—Samples Nos. 206 and 207 were simply analysed to check the results obtained in one of the laboratories recently established, to enable its owner to guarantee the composition of the fertilizers sold by him. Sample No. 206 is so abnormally rich in nitrogen that I feared there was something wrong with the determination, but it was all right. The minimum percentage of nitrogen given for Kurdi is 3·22 notwithstanding that an old sample of unknown source gave less than 3 per cent of nitrogen. In no other fertilizer does there appear to be so much range in quality as in Kurdi, or safflower cake.

60. The figures connected with the other varieties of oil-cake given above, require no special mention.

61. As to the difference in the intrinsic value of different samples of oil-cakes of the same kind, I refer to page 24 of the Fifth Annual Report, page 15 of the Fourth Annual Report and page 12 of the Third Annual Report of this Department.

62. *Bone and fish.*—The following table giving the composition of dried fish and bone meal require no special comment. A variety of fish called bungara gave the maximum results, and a small variety of fish called by the sender sardines gave the poorest returns. The sample of bone meal giving the poorest results was undoubtedly adulterated.

TABLE No. X.

Bone and fish.

No.	Substance	Results of previous years						Analysis, 1904-05		Locality
		Nitrogen			Phosphoric acid					
		Average	Minimum	Maximum	Average	Minimum	Maximum	Nitrogen	Phosphoric acid	
	Dried fish ...	6·01	3·96	8·72	5·03	1·73	7·51	...	...	
56	Do ...	...	...	...	...	...	...	4·48	4·53	West Coast.
57	Do ...	...	...	...	...	...	...	6·33	3·61	Do
	Bone meal ...	3·58	2·52	4·04	22·38	18·62	23·36	...	...	
71	Do ...	...	...	...	...	...	...	3·77	22·83	Bangalore

FERTILIZERS OTHER THAN THE ABOVE.

63. The number of inquiries received as to whether the acid sulphate of potash formed as a by-product at the Cordite factory at Wellington could be used as a fertilizer,

shows that there is a strong desire to make use of any substance likely to be valuable for manurial purposes. Unfortunately the small percentage of lime found in most South Indian soils makes it highly probable that this acid sulphate of potash is not likely to be of much value as a manure. It is more likely to be a poison to plant life. But so far no experiments have been made with it to test these points. Probably if mixed with an equal quantity, or more, of freshly burned lime, it would do very well as a manure ; but as lime is rather expensive and as its value as an indirect fertilizer would, to a very large extent, be lost if used in this way, this recommendation has not found favor, and no experiments have, as far as I know, been made to see if such a mixture would be satisfactory. Messrs. Stanes & Co., of Coimbatore, have mixed this acid sulphate with bone meal in the hope that the acid sulphate would act on the bone in something like the same manner as sulphuric acid would do. But as both the acid sulphate and the bone meal were in the form of a powder, they did not have much chance to react on each other. However from the analysis of this mixture it is evident that some reaction has taken place, for in this mixture were found 8·09 per cent of phosphoric acid soluble in a neutral solution of ammonium citrate (the re-agent used for determining the "available phosphoric acid" in fertilizers), and as owing to the increase in bulk due to the addition of the acid sulphate of potash, the total phosphoric acid was reduced from about 23 per cent to 13·58 per cent. This mixture had 59·57 per cent of its total phosphoric acid in an available form. As none of the untreated samples of bone meal which had been used for this mixture accompanied it, another sample of bone meal was analysed and found that in it 27·16 per cent of the total phosphoric acid were in an available form. If the two samples of bone are nearly alike, and it is reasonable to suppose this, there can be no doubt that the acid sulphate, even in the form of a powder had some action on the bone meal ; and as the injurious effects of the acid sulphate are reduced in exactly the same proportion as the sulphate acts on the bone meal, it is quite possible that if the acid sulphate is applied in the form of a concentrated solution to finely

powdered bone meal, its injurious action as a fertilizer may be turned to good account in making the bone meal more available. Messrs. Stanes & Co., of Coimbatore, have kindly promised to make this experiment, and the produced sample will be analysed and some pot-culture experiments made with it in this Department.

64. *Trichi phosphate.*—As a large number of inquiries were received in regard to this phosphate, a sample was analysed notwithstanding that, as it is a rock phosphate, it is not likely to be of much use as a manure unless converted into superphosphate. It was ground very fine and practically all passed through the standard (100 meshes to an inch) sieve. But, as will be seen from the table given on p. 49, practically none of the phosphoric acid was soluble in a neutral solution of ammonium citrate, and therefore judged by the European and American standard, practically none of it is available.

65. *Bone char.*—The bone char, a refuse from the sugar refinery, contained a comparatively large amount of nitrogen for a substance of this kind. But as bone char is considered to be practically inert unless treated with sulphuric acid and transformed into superphosphate, the amount of nitrogen cannot make it a fertilizer which could be recommended. Moreover the nitrogen contained in it is likely to be itself very inert.

66. *Aloe fibre refuse.*—A sample of dried aloe fibre refuse sent from the Shevaroy Hills was found to contain 1·64 per cent of nitrogen. This is not sufficient to justify it being carried long distances when intended to be used as a fertilizer. It is not far short in nitrogen of the poorest sample of ippe poonac analysed here. But as it is fairly bulky and possibly the nitrogen in it is not quite as available as that in poonacs, it cannot be considered as a commercial fertilizer. Its bulky pithy nature are however likely to make it an excellent mulch where such can be applied. And as a mulch is in itself of great value, the aloe fibre refuse will have to be considered as a useful by-product of the aloe fibre industry if used in the neighbourhood of the factory.

67. *Ashes.*—Considerable quantities of wood ashes are used annually for manurial purposes. These are generally prepared specially for that purpose by burning brushwood; and the heat produced by the burning is not utilized in any way. Some of these ashes are, however, so poor in potash that it cannot possibly pay to make them even if the wood is valueless and there is little other work for the coolies at the time. Nos. 60 and 62 in the following table are of this nature. Both of them contain less than 1 per cent of potash soluble in hydrochloric acid, and of this amount not much more than half is soluble in boiling water, and therefore readily available. A ton of these ashes would therefore be worth less than Rs. 3. Samples Nos. 30 and 32, which are also produced from mixed woods, are very much better in quality being more than twice as valuable ; but even these are low in potash. Both samples Nos. 63 and 64 are however valuable samples of ashes. But the best of these analysed thus far is No. 33, a sample of bamboo ashes received from Coorg. But strange to say, probably owing to the light weight of these ashes, they have generally been considered to be of but little value. Some other wood ashes such as Lantana will be analysed soon. If their percentage of potash should happen to be high it may help in solving the problem of stopping the Lantana invasion. It is a pity, however, to see wood other than Lantana burned solely for the sake of the ashes.

TABLE No. XI.

Ashes and miscellaneous fertilizers.

No.	Substance	Nitrogen	Phosphoric acid	Phosphoric acid soluble in ammonium citrate	Potash	Potash soluble in water	Lime	Loss on ignition	Insoluble residue
		4·04	23·34	6·34	...	...	...	...	...
188	Bone meal	...	13·58	8·09	...	...	...	...	...
	Bone meal treated with about its own weight of dry acid sulphate of potash	...	25·51	0·38	...	...	43·86	...	...
204	Trichi phosphate	1·21	27·80	...	...	16·71	...	...	...
37	Bone char	3·63	...	...	...	39·58	...	...	...
31	Crude saltpetre	12·95	...	...	...	...	...	...	...
54	Refined do	1·64	...	...	...	...	11·51	26·90	45·54
187	Aloe fibre refuse	...	1·15	...	·93	0·61	...	15·54	...
29	Ashes	...	...	...	·78	0·40	...	...	...
60	Ashes, mixed wood	...	...	...	4·82	2·53	...	...	...
62	Do do	...	...	...	3·47	1·90	...	...	...
63	Do bratty	...	...	...	2·32	..	17·43	20·24	44·50
64	Do chetty burners	...	0·57	...	1·97	...	29·04	28·94	24·40
30	Ashes mixed wood	...	1·45	...	5·40	...	...	...	...
32	Do do	...	2·54	...					
33	Do bamboo	...							

Miscellaneous.

68. *Purifying water with alum.*—At the request of the Deputy Chief Engineer, some observations were made in regard to the amount of alum required to clear the water of the Hessarghatta tank. It is of course difficult to state exactly when the settling of the suspended matter began

and there is also some difficulty, in a simple observation like this, to find out when the water is practically clear, as a considerable quantity of the fine suspended matter clings to the side of the glass vessel. But for practical purposes the figures given below are accurate enough, and may be of help to those wishing to clear water for domestic purposes. The water was very turbid. But two grains per gallon or about one ounce for 200 gallons was all that was required to practically clear the water in seven hours and was almost as effective as four times that quantity ; but it is the minimum quantity which gave good results. One and a half grains per gallon proved to be inefficient unless the water could be allowed to stand quietly for a day or more.

TABLE No. XII.

Alum grains per gallon	Began to settle in hours	Practically clear in hours
8	2	5
5	3	5
4	3	5
3	3	5
2	3	7
$1\frac{1}{2}$	5	27
1	96	...
0	...	...

69. *Salt.*—Two samples of sea salt were analysed. The one contained 84 per cent of salt, the other 92 per cent. The poorer sample contained, in addition to the salt 1·64 per cent of magnesia, and some lime, potash and sulphuric acid (of course all combined). The better sample contained 0·77 per cent of magnesia, and of the other impurities mentioned above, it contained about half the quantity found in the poorer salt. The remainder of the impurities were sand and other insoluble matter and water.

70. *Famine food.*—Twenty-two other samples of famine foods were sent in, and in all of them the nitrogen has been determined. On the average the nitrogen content

is a little higher than that of those analysed last year though both the highest and lowest percentage of nitrogen is very much lower than last year. The highest was 2·70 per cent found in a sample of Kannay leaves sent by the Amildar of Malur; but there were several other samples nearly as rich. The poorest contained only 0·05 per cent of nitrogen. It was a sample of Godirsaadagadde flour sent by the Deputy Commissioner of Shimoga. But no other sample received had anything approaching this low percentage of nitrogen.

71. As samples of famine foods are still being sent in to the Laboratory, and as some other constituents, for example, crude fibre, fat or ether extracts, and amide nitrogen, have to be determined to judge of the food value of these famine foods, the results obtained this year and those already published last year on pages 26-28 of the Fifth Annual Report will be published together when the analytical work regarding the nutritive value of these foods has been finished. If some senior officer in the Mysore service well acquainted with these famine foods and the peculiarity of the people who might have access to these foods in time of famine could be deputed to write a bulletin on these foods in conjunction with the Agricultural Chemist when the analytical work is finished, that bulletin would doubtlessly be of much more value than the bare statement of the analytical results would make it.

A. LEHMANN,
Agricultural Chemist.

Acc no 6099

DEPARTMENT OF AGRICULTURE, MYSORE STATE.

SEVENTH ANNUAL REPORT

OF THE

AGRICULTURAL CHEMIST

FOR THE YEAR 1905-1906.

Kanarese and English Reports and Bulletins of the Department of Agriculture will be sent free to Planters, or Raiyats, who apply for them, so long as the supply lasts.

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SEVENTH ANNUAL REPORT OF THE AGRICULTURAL CHEMIST FOR THE YEAR 1905-06.

PART II.

22. Part I, consisting of paragraphs 1 to 21, is not published for general circulation.

Experimental Farm.

23. As stated on page 1 of the 6th Annual Report of this Department, 30 acres of land were acquired for the purpose of starting an Experimental Farm near Hebbal village about 5 miles from Bangalore. These lands were taken possession of in January 1905. A description of the land and its location is given in the same report, and two maps showing the original numbers of the fields (and differences in level of these fields in the wet area) are also attached to that report. On these maps the plots of the new Experimental Farm, the roads, paths, irrigation channels and drainage channels are given.

24. The wet area consists of three ranges, each having 17 plots of one-tenth of an acre. Two of these ranges are on the same level and are intended for experiments with paddy. The third range is at a higher level and is intended for experiments with sugar-cane. The remainder of the land is composed of irregular plots which are not intended for experiments at present. The entire area is surrounded by a drain to prevent percolation of water from the adjoining land, and each plot can be drained or irrigated independently of any other plot. The paddy plots are half a chain wide and two chains long and are each divided into three equal sections.

25. The dry area has four ranges of 19 plots each. Besides this there are 27 other plots ; all are half a chain wide and two chains long. The remainder of the dry land comprises irregular land not suited for experiments.

26. The principle underlying all experiments is, of course, to have all the conditions which may possibly influence the growth of the crop the same, excepting the one factor experimented with. If, for example, one kind of phosphatic manure is to be compared with another kind of phosphatic manure, the same kind and quantity of nitrogenous and potash manures must be used, and care must be taken that a sufficient quantity of these is supplied. The cultivation must be exactly alike in all respects. It must be done, if possible, by the same implement, to the same depth and at the same time. The climatic conditions must be the same and favourable so that they do not form the weakest link in the chain of factors influencing plant growth. The soil must be absolutely uniform and of good mechanical condition. And the seed used must not only be of the same variety but of the same size and quality and sown at equal distances apart on the same day. These are some of the details which have to be attended to if absolutely reliable results are to be obtained. This matter, which has been referred to in more detail on page 5 of the Fourth Annual Report of this Department, is a very important, but unfortunately an equally difficult one. In fact it is impossible to carry out these conditions on an experimental farm, and for that reason field experiments are never absolutely accurate and have to be repeated very often and be very carefully watched if useful results are to be arrived at. The soil is rarely if ever absolutely uniform, and the other conditions vary more or less. It is therefore utter folly to attribute to any one set of field experiments absolute accuracy. All field experiments are likely to have some error attached to them, and it is the duty of the experimentor to determine as nearly as he possibly can what the magnitude of that error is likely to be. Unfortunately, many field experiments have been started on land

which has not been tested at all before the experiments were begun. The desire to get results as quickly as possible has led the experimentors to trust that the soil is uniform enough, because it appeared to be so to the eye. But without having a thorough knowledge of each individual plot before beginning the experiments the experimentor is very much in the dark later on, and is unable to intelligently interpret such results as have been obtained unless indeed he has had the very rare good fortune to hit upon a field which is fairly uniform not only in appearance but in reality. The liberal use of duplicate plots will give him some idea, when the experiments are well under way, whether the soil is fairly uniform or not. But if it does not happen to be uniform, they can simply betray this fact and condemn the experiments.

27. The lands of the Experimental Farm are the most suitable which could be found within reasonable distance of Bangalore. They appeared to be practically, but not absolutely, uniform to the eye. It was therefore necessary to test them carefully and determine the extent, if any, of the differences existing in the soil. Besides this, the acquired land had been in the hands of different owners and had been treated differently, and this difference in treatment had to be eliminated by a system of uniform treatment before experiments could be begun, even if the land had naturally been uniform to begin with. A third reason for having to give the land uniform treatment for a time was to try to get rid of some of the weeds which were in the land.

28. The dry land has grown one crop of ragi, and two of the ranges of wet land have grown two crops of paddy, the third has produced one crop of paddy, and a crop of sugar-cane is growing on it now.

29. In Table No. I following are given the weights of paddy produced on the plots of the wet area.

TABLE I.

Weight in lbs. of paddy grown on the Experimental Farm at Hebbal.

Plot	Range A	Range B		Range C	
	1905	1905	1906	1905	1906
1	337	354	434	313	233
2	303	330	421	295	284
3	346	319½	404	297½	260
4	301	379½	379	303½	252
5	306½	338	318	293½	284
6	356	349	289	303	316
7	327	334½	342	268½	252
8	289	256	258	251½	226
9	316	214	249	240	207
10	288	260	259	234	225
11	317	254	236	233	198
12	285	236	258	204	198
13	284	259	250	204	216
14	228	285	289½	201	221
15	296	244	259	207	213
16	326	221	225	215	218
17	288½	221	208	199	171
Total ..	5,194	4,854½	5,078½	4,262½	3,974
Average ..	305·53	285·56	298·72	250·72	233·77

30. The crop grown in 1906 was harvested in very wet weather, and it is possible that the grain from different plots contained different amounts of moisture. The grain will have to be re-weighed later on to get accurate results, but figures given now are probably not far from the truth and serve to illustrate that in addition to the soil other factors affecting plant growth have not been quite uniform.

31. The total crop of paddy reaped from Ranges A and B together in 1905 is 9,117 lbs., that for 1906 is 9,052½ lbs., a difference of less than ¾ per cent. The

two crops may therefore be considered as identical in quantity. Still there is a considerable difference in the crops produced on some of the individual plots in the two years. The greatest difference in crop for the same plot in the two years was in plot No. 2, Range B. It gave 91 lbs. of grain more this year than last year. This is an increase of 27½ per cent on last year's crop, which is apparently due to some other factor than difference in soil. We have not yet determined what that factor is. It may be due to any one or more of a large number of factors. In both ranges the plot with the greatest variation in the crops of the two years is situated very close to the western limits of the experimental field right under the tank bund. Possibly the water-supply may not have been as uniformly distributed as it should have been. But whatever the causes are, they are probably not directly connected with the soil itself, so that, as stated above, other factors as well as the soil have varied in this set of experiments.

32. Taking the ranges by themselves, Range B gave 4·62 per cent more, and Range C 6·70 per cent less, paddy in the second year, and the average difference in the individual plots for the two seasons is 8·31 per cent in Range B, and 8·21 per cent in Range C. Out of the 34 plots 23 showed differences lower than these averages. There are only a few plots therefore in which the differences in crop of the plots which are supposed to have been treated uniformly are greater than 8½ per cent when comparing the crops of the two years. If all the plots could have been kept within this range of experimental error, the results would have been satisfactory indeed.

33. The less difference there is in the yield of crops, after making due allowance for difference in season and soil, the less the experimental error and the more reliable the results obtained after the experiments proper have been begun. The greater the differences between the various crops of the same plot, the longer of

course the preliminary experiments must be continued in order to determine as accurately as possible both the limit and the average of the experimental error.

34. By comparing the highest yield which was obtained from any of the plots with the lowest one, we have some index of the difference existing at present in the soil. And as this difference exceeds by over 200% the greatest difference existing between the returns in the two different years from any one plot, it is a strong indication that there is some considerable difference in soil. This is further confirmed by the fact that none of the plots which have given comparatively high results one year have given very low results the next year or *vice versa*. But before any definite statement as to the extent of the difference in the soil can be made, some further test crops will have to be grown.

35. The fact that these differences in the soil exist makes it more difficult to make experiments on them. But with a judicious disposition of duplicate plots this difficulty can be overcome, in a very large measure at least, provided that there is reliable information as to the relative extent of these differences. Of course it is much easier and also more satisfactory to conduct experiments on an absolutely uniform piece of land. But unfortunately such a piece of land cannot always be found even if considerable time is spent in looking for it. On the piece of land selected for the experimental farm 75 borings were made to the depth of two feet and 150 samples of soil were taken and examined to test its uniformity. A somewhat similar, though less extensive, examination was made of all other lands which presented a somewhat uniform appearance and would have been otherwise suitable. As it was impossible to get an absolutely even piece of soil, the greatest possible care will have to be taken in standardising the different plots selected for experiments.

36. *Distance of planting.*—The paddy grown on the wet area as a test crop was transplanted in the ordinary

way. The distance between the plants was not measured but simply judged by the eye. Two plants were put in together. To form some idea of the error liable to be introduced in this way by not having the plants at uniform distances the stalks in a small measured area were counted in each of the sub-divisions of the plots. The way employed to do this was to take a light wooden frame $17\frac{7}{10}$ inches square inside measure, lay this on the stubble of the section of the paddy plot and cut off close to the ground all the stubble enclosed by this frame. This cut stubble was put into a labelled bag and counted afterwards. The farther the plants were planted apart the greater the number of stems produced by the one plant has been as a rule. In fact, as a general rule, any difference in the distance of planting appears to have been largely compensated for by difference in tillering. In Table No. II are given the results of this counting :—

TABLE II.

Showing the number of stalks, plants and grain grown in area $17\frac{7}{10}$ *inches square.*

RANGE C.

Plot No.	Number of stalks in section			Number of plants in section			Average number of stalks in sections *a, b, c*	Average number of plants in sections *a, b, c*	Grain produced, calculated, lbs.
	a	*b*	*c*	*a*	*b*	*c*			
1 ...	46	48	54	10	9	10	49·33	9·66	·1165
2 ..	66	52	54	9	7	9	58·66	8·33	·1420
3 ..	64	67	57	10	7	11	62·66	9·33	·1300
4 ...	54	57	54	12	9	11	55·00	10·66	·1260
5 ...	72	67	64	10	9	10	67·66	9·66	·1320
6 ...	49	45	60	10	9	8	51·33	9·00	·1580
7 ...	65	56	59	10	10	11	60·00	10·33	·1260
8 ..	57	59	60	9	9	9	58·66	9·00	·1130
9 ...	48	53	49	9	9	8	50·00	8·66	·1035
10 ...	44	58	51	10	9	8	51·00	9·00	·1125
11 ...	52	51	53	10	10	8	52·00	9·33	·0990
12 .	52	47	59	8	10	8	52·66	8·66	·0990
13 ...	51	57	61	8	9	10	56·33	9·00	·1080
14 ...	56	36	56	10	9	9	49·33	9·33	·1105
15 ...	47	47	46	9	10	8	46·66	9·00	·1065
16 ..	61	52	51	11	9	9	54·66	9·66	·1090
17 ..	45	56	43	10	10	10	48·00	10·00	·0855
Total ...	929	908	931	165	154	157	923·94	158·61	1·9770
Average	54·65	53·41	55·00	9·71	9·06	9·23	54·35	9·33	·1163

Plot 3, section (*b*), has only seven plants, but these seven plants have produced 67 stalks, while in section (*a*) ten plants have produced 64 stalks and in section (*c*) eleven plants produced only 57 stalks. In the next plot and throughout the table similar instances may be found. But plants the same distance apart do not always produce the same number of stalks. Nine plants in plot 5, section (*b*), produced 67 stalks. Other nine plants the same distance apart in the same section of the next plot produced only 45 stalks, and this reduced number of stalks cannot be accounted for by the soil in plot 6 being poorer in quality, for that plot

has given a heavier crop of paddy than No. 5. Plot No. 6 also illustrates that the crop does not necessarily depend on the number of stalks produced.

37. *Dry lands.*—All the experimental area of the dry land was ploughed twice with a Canadian plough and cultivated with a "Planet Junior Horse Hoe" before being sown with ragi on July 11th and 12th. No manure was applied. The seed was sown with a local seed drill and all subsequent cultivation was the same as ordinarily practised by the raiyats in the neighbourhood. In various places near the western boundary of the Farm (the plot numbers begin from the west) garden crops had been grown by the previous occupants of the land. These places were well marked by the stand of the ragi growing on them and the boundary lines of these plots were even more apparent in the field when the ragi was growing than appears in the table of results given below. As only one crop of ragi has been reaped thus far, no analysis of the figures obtained is possible. The plots in themselves vary very considerably. But when comparing the ranges as a whole they are very much more uniform, varying not quite 27 per cent. That is, the range giving the highest yield gave 26·9 per cent more grain than that giving the lowest yield.

TABLE

Returns from experimental area of dry land, weight of

Plot No.	Range A		Range B		Range C	
	Straw lbs.	Grain lbs.	Straw lbs.	Grain lbs.	Straw lbs.	Grain lbs.
1	760	274	280	149	294	146
2	770	248	320	198	277	172
3	632	205	259	320	327	139
4	760	323	322½	186½	270	183
5	688	362	308	188	356	184
6	561½	180½	342½	198½	363	185
7	269½	245½	323	181	314	185
8	309	195	364½	195½	365	192
9	309½	201½	325	202	303	207
10	308	175	357	214	330	192
11	362	189	322½	197	315½	168½
12	405	211	316	202	320	178
13	332	252	344	188	360	148
14	347	213	295	179	332	153
15	357½	210½	305	185	376	163
16	Nulla		Nulla		Nulla	
17	187½	100½	201	137	109	153
18	222½	122½	271	153	181	106
19	211	159	282	152	200	146
20	193	98½	268	158	265	142
21	...	...	...	...	...	...
Total...	7,985	3,965½	5,806	3,583½	5,657½	3,142½
Average...	420·26	208·71	305·58	188·61	297·74	164·45

III.

ragi (straw and grain) per plot of 1/10 acre.

Plot No.	Range D		Range E		Range F	
	Straw lbs.	Grain lbs.	Straw lbs.	Grain lbs.	Straw lbs.	Grain lbs.
1	755	361	579	246	355	205
2	618	252	625	262	419	218
3	581	279	520	253	331	173
4	435	249	518	166	422	206
5	339	174	390	262	462	226
6	364	199	392	253	429	226
7	241	130	477	193	567	231
8	265	167	493	184	692	248
9	253	172	468	245	803	241
10	270	178	437	185	741	253
11	243	153			192	116
12	247	158			232	174
13	238	183	Buildings		220	151
14	236	126			232½	129½
15	253	162			273	133
16	Nulla				327	142
17	232	188	191	119	356	206
18	242	129	283	191	272	169
19	163	177	276	141	338	187
20	283	165	172	155	302½	201½
21	...	...	158	154	294	154
Total..	6,258	3,602	5,979	3,009	8,261	3,990
Average...	329·37	189·58	398·60	200·60	393·38	190·00

38. Adjoining the southern boundary of the Farm were ragi fields which were ploughed and cultivated by their owners in the ordinary way excepting that these fields received a dressing of cattle manure. During the entire growing season these crops appeared to be much poorer than those adjoining it (separated only by a wire fence) growing on the Experimental Farm. The land on the Farm had been ploughed deeper but had received no manure. To find out how far this apparent difference was a real one, the Farm Superintendent obtained permission to harvest and thrash a narrow strip along the entire southern boundary line of the Experimental Farm. The area of this strip was nearly ·73 of an acre. The grain produced on this strip was 759½lbs. and the straw 1,936½lbs. As this strip is comparable with a range of the Experimental Farm and as those ranges have given fairly uniform results, it is reasonable to suppose that if there had been another range just to the south of the Farm it would, under similar treatment, have given results comparable to the other ranges. But this outside strip has, after making allowance for the maximum difference between the ranges on the Farm, only produced half the crop per acre. This difference in crop was attributed by the villagers to the difference in ploughing, and as a result there was a strong demand for ploughs like those used on the Farm. But as no ploughs had been imported for sale and the Kolar Mission, who sell a somewhat similar plough, had run out of stock, this demand could not be supplied. And as this one season's result is by no means conclusive, notwithstanding that it appeared to be so striking to the villagers, I am not at all sorry that the villagers could not have their wishes satisfied; for perhaps it may save them a disappointment later on. But it is encouraging to notice this interest taken by the villagers in a thing they expect to be a marked improvement on their own.

39. *Thrashing machine.*—A "hand-thrashing machine" which had given very good satisfaction at the

Experiment Station in Darmstadt, Germany, was imported and tried here with ragi. Four coolies were able to turn it, but as this was harder work than they could stand for long, a bullock power was used instead. As received, the thrashing machine broke a considerable quantity of grain, enough to affect the market price of the latter. But by substituting round teeth in the cylinder and concave for the rectangular ones originally sent with the machine, the breakage was practically avoided altogether. In one of the tests some breakage appeared to have taken place. But as the thrashing was done on a stone floor and the grain removed with an iron implement, and as no breakage of any account occurred when the thrashing machine stood on an earthen floor, the breakage in the test referred to was probably done after the grain had passed through the machine. On the average three-quarters of a ton of ragi straw could be put through the machine in an hour when four pairs of bullocks were used. With the rectangular teeth the machine removed all but $2\frac{1}{2}$ per cent of the grain; at least that was the quantity of grain obtained when re-thrashing the straw. The drawback to a small American thrashing machine imported by the Kolar Mission is said to be that instead of completely separating the grain, a large portion of heads are torn off with the grain left in them; these have to be re-thrashed by hand. In the test here with the German machine the ear heads torn off contained 7·28 per cent of the grain. In these small machines there is no provision for separating the loose grain from the chaff and ear heads. All these are left together and have to be separated afterwards. No satisfactory test as to the amount of ragi left in the straw has been made as yet with the round teeth, but the indications are that the amount of grain left in the straw is greater than when the rectangular teeth are used. The number of ear heads torn off is also greater. But as stated before, there is practically no grain broken by the round teeth.

40. The ragi grown on the experimental plots had to be thrashed in the ordinary way with bullocks. To

test if this work had been thoroughly done all the ragi straw was re-thrashed some time later by machine. In Table No. IV are given the results of this re-thrashing.

TABLE IV.

Ragi straw thrashed in the ordinary way with bullocks, re-thrashed by machine. First thrashing gave 34·75 per cent grain and 65·25 per cent straw.

No.	Weight of straw re-thrashed	Ragi thrashed from straw by machine			Weight of grain left in straw per 1,000 lbs. of crop as cut	Per cent of total grain left in straw	Weight of grain left in straw per acre
		Clean grain	Grain in earheads torn off	Total			
	lbs.	lbs.	lbs.	lbs.	lbs.	%	lbs.
1 ...	1,120	21	7	28	16·3	4·48	85
2 ...	1,120	20	8	28	16·3	4·48	85
3 ...	1,120	18½	2	20½	11·9	3·31	63
4 ...	1,120	19½	4½	24	14·0	3·87	73½
5 ..	1,089	25	5	30	18·3	5·00	95
6 ...	1,120	24	6	30	17·5	4·79	91
7 ..	1,120	24	3½	27½	16·0	4·40	83½
8 ...	1,120	22	4	26	15·2	4·19	79½
9 ...	1,120	25	4½	29½	17·2	4·72	89½
10 ...	742	20	5	25	22·0	5·95	113
11 ...	1,120	20	5	25	14·5	4·00	76
12 ...	1,120	16½	4¼	20¾	12·1	3·36	64
13 ...	1,120	17½	3	20½	11·9	3·31	63
14 ...	1,120	19	4	23	13·4	3·71	70½
15 ...	1,120	16½	6	22½	13·1	3·63	69
16 ..	1,120	18½	5½	24	14·0	3·87	73½
17 ...	1,120	18½	5	23½	13·7	3·79	72
18 ...	1,120	15	2½	17½	10·2	2·85	54
19 ...	1,120	19	4	23	13·4	3·71	70½
20 ...	239	7½	1	8½	22·8	6·15	117
Total ...	21,110	387	89¾	476¾	303·8	83·57	1,587½
Average ...	1055·50	19·35	4·49	23·84	15·2	4·18	79·37

Nos. 5, 10 and 20 were from the bottom of the stacks of straw, and the larger amount of grain found in them is probably due to the loose grain of the layers above having accumulated in these, a thing of common occurrence. On the whole the results are very satisfactory, showing that the grain had been thrashed well. To show that these small amounts of grain left in the straw nevertheless amount to an appreciable loss of grain per acre, these amounts are given in a separate column in the table above.

41. For thrashing paddy the machine appears to be well suited. At least no difficulties have been noticed up to the present. As might be expected, a much larger weight of paddy in the sheaf could be thrashed than loose ragi straw. But the amount of paddy in the sheaf thrashed this year at any one time was too small to admit of the records of time being very reliable. As far as they go they indicate that about 2 to 2½ tons could be thrashed per hour.

Laboratory Compound.

42. *Ragi.*—The little plots on which ragi has been grown the past two years were again sown with ragi. No manures were applied this year, the object being to see how soon the yields from the individual plots would become comparatively constant again. Last year the uneven nature of the plots did not permit of ascribing any of the difference found in them as due to the after-effect of any of the manures applied the previous season, and the figures gave practically no information that year. But this year's results give some value to the figures obtained last year even though, owing to the small area of the plots, the naturally poor condition of the soil, and the uneven nature of the soil, these figures are far from being as valuable as they otherwise would be. But these experiments are, as stated in the Fifth Annual Report, page 10, only a preliminary set of experiments solely intended to help in planning future experiments

and not intended to give any definite results themselves. Still, this year's figures appear to indicate that last year there was some after-effect even from poonac and bone meal. This is especially noticeable in plot 6. On the whole the last crop was considerably less than of the previous year. This is no doubt partially due to some of the plots being manured last year, while none were manured this year. But even if it were totally due to season and a correction were applied for this, there would still be a very marked decline in this year's crop of plot No. 6, so that apparently this plot has depreciated in productiveness. But as plots Nos. 3 and 14 have actually given a heavier crop this year than last year, and as some others have given nearly the same results, the decline in the average return cannot be solely due to season.

43. On the whole the plots appear to have become more uniform in character than they were at the beginning. There is little difference this year in the average of the crops raised on the land ploughed with the Mysore plough and that ploughed with the Canadian plough, provided only those plots which have been treated otherwise in the same way are considered. The plots dug two feet deep have, however, given a heavier crop than those simply ploughed, notwithstanding that the soil, as indicated by the first experiments, appears to be a little better in plots Nos. 6 and 13 (those simply ploughed) than in plots Nos. 8 and 15 (those dug deep). But it must not be forgotten that these experiments are only intended to serve as an index for future experiments and are not intended to give in themselves results which could with safety be applied to general agricultural practice. In Table No. V are given the results of the three years' crop.

TABLE V.

Experiments with ragi in Laboratory Compound.

Plot No.	Cultivation	Manuring		Yield in grain calculated per acre		
		Nature	When applied	1903	1904	1905
2	Ploughed with Mysore plough.	No manure ...	..	168	537	237
9	Do .	Do ...	...	318	...	370
3	Do ...	Cattle manure ...	1903	431	475	705
	Do ...	Do ...	1903-04	...	850	1,050
10	Do ...	Do ...	1903	656	800	750
	Do ...	Do ..	1903-04	..	1,150	1,100
4	Ploughed with Canadian one-horse plough.	No manure ...	...	...	712	400
11	Do ...	Do ..	...	700	...	662
5	Do ...	Cattle manure ..	1903	381	675	575
	Do ...	Do ...	1903-04	...	750	750
12	Do .	Do .	1903	743	1,075	800
	Do ...	Do .	1903-04	...	2,125	1,050
6	Do ..	Poonac, bone and muriate of potash	1903	1,472	825	525
	Do ...	Do ...	1903-04	...	2,025	975
13	Do ...	Do ...	1903	2,062	700	675
	Do ...	Do ...	1903-04	...	2,225	1,050
7	Do ..	Double quantity poonac, bone and muriate of potash.	1903	1,400	1,050	1,075
	Do ...	Do ..	1903-04	...	1,325	1,325
14	Do ...	Do ...	1903	1,900	1,075	1,325
	Do ..	Do ...	1903-04	..	..	1,425
8	Dug 2 feet deep.	Poonac, bone and muriate of potash, same quantity as in plots 6 and 13	1903	1,371	975	1,300
	Do ...	Do ...	1903-04	...	1,800	1,325
15	Do ...	Do ..	1903	1,362	1,450	1,175
	Do ...	Do ...	1903-04	...	1,150	1,350
	Average ...	Do ...	...	...	1,131	896

44. *Ground-nuts.*—The ground-nuts were quite as badly diseased this year as last year. The treatment of the seed with one per cent solution of copper sulphate appears to have had a slightly beneficial action. Below is given the yield given by the treated and the untreated seed calculated per acre. But as this is only the result from one year's test, the experiments must be repeated before they can carry weight.

TABLE VI.

Yield of ground-nuts from seed treated with copper sulphate compared with that from untreated seed.

Variety	Yield calculated per acre in pounds			
	1903	1904	1905	
			Treated	Untreated
Virginia ...	10,100	3,550	2,810	2,386
Japanese ...	8,950	4,100	2,945	2,103
Pondicherry ...	6,925	4,550	1,996	1,864

45. *Caravonica cottons.*—Nos. 1 and 2 have been grown in the compound in a small plot, and judging by present appearances they may possibly give very fair returns. They were, however, irrigated whenever the soil got dry, and received throughout the best of treatment.

SUGAR-CANE.

46. A small patch of sugar-cane was grown on "new" ground to supply material for making tests in milling, to study the deterioration of the cane after cutting and such other factors as last year's experiments had suggested. The plants germinated very poorly, many of the sets being eaten by white ants, and others were incured; and later on, many of the canes were attacked by the borer, some very badly. The cane when ripe for jutting varied so much that it was impossible to select

small samples sufficiently uniform to test the depreciation of cane after being cut. Two attempts were made to get uniform samples for this work, but both failed. The cane was used to make some of the milling tests given below; and an experiment is in progress to test the injury done to the quality of sugar-cane by borers.

47. *Extraction.*—This year the percentage of juice extracted from sugar-cane by four different mills was tested; two of these were bullock mills, one, a locally-made one with rollers $6\frac{3}{4}$ inches in diameter, the other from Northern India with the two main rollers $8\frac{1}{2}$ inches in diameter and the feed roller 7 inches in diameter. The other two were a larger mill imported from Scotland driven by a $6\frac{1}{2}$ horse-power oil engine with rollers 12 inches in diameter and a small American hand sugar-cane mill in which the rollers were 5 inches in diameter. All these mills have three rollers and were set as tight as circumstances permitted. The results are given in Table No. VII on page 22.

TABLE VII.

Extraction.

Mill	How set	Power required to drive	Cane milled per hour,	Extraction calculated on weight of begasse	Mark in cane	Per cent of juice left in begasse	Loss of sugar per acre, taking that 20 tons of cane are grown per acre,	Per cent of sucrose in juice
			lbs.				lbs.	
(1) Local bullock power cane mill. Average of 30 experiments.	Tight	Same as No. 8	...	67·4	8·77	26·10	1,919	18·0
(2) Power mill...		6½h.p.	...	75·98	8·10	17·33	1,276	17·9
(3)	...	...	1,852	77·76	7·26	18·31	1,095	14·4
(4)	...	...	1,971	74·24	8·54	18·83	1,118	14·5
(5)	...	...	1,911	...	7·97	18·16	1,163	15·6
(6) Hand mill. Average, first crushing.	...	Easily turned by one cooly	115	66·3	7·95	28·74	1,931	16·3
(7) Hand mill. Cane passed through twice.	...	...	...	75·14	7·95	18·37	1,234	16·3
(8) Local bullock mill. Three canes at a time.	...	Average about 105 lbs.	222	66·5	8·00	27·70	1,918	16·8
(9) Nahan bullock mill. Three canes at a time.	...	Average about 165 lbs.	325	69·1	8·00	24·90	1,724	16·8
(10) Nahan bullock mill. Four canes at a time.	...	Average about 205 lbs.	400	68·2	8·00	26·00	1,800	16·8

Both the cattle mills had vertical rollers; the other two, horizontal rollers. The hand-power mill crushes about 115 lbs. of cane per hour and is only intended for crushing samples for analysis. It is included in this list because it is the only mill through which the cane has been passed a second time. The first crushing with the hand sugar-cane mill left very nearly the same amount of sugar in the refuse as the local cattle mill

had done. But by passing this refuse through the mill again fully one-third of the juice left in that refuse was removed. Taking that 20 tons of that particular kind of cane had grown per acre this would have saved about 700lbs. of sugar per acre, or in round numbers, nearly 40 maunds of jaggory per acre. If the cane has been as well milled as it was with the cattle mill here, the refuse is so torn up that it cannot be fed through a vertical mill a second time. It is only a horizontal mill fed by a cane-carrier which would make such a course practicable.

48. The power mills saved on an average, compared with the cattle mill, 756lbs. of sugar per acre, again assuming that the crop is 20 tons of cane per acre. This made a difference of about Rs. 50 per acre, taking into account simply the better extraction this mill gave. But besides this, the difference in the expense of running a mill by bullock power and by an oil engine will have to be considered.

49. The average of a few tests, comparing the local mill with that from Northern India, showed that the imported mill crushed considerably more cane per hour when both were fed with three canes at the time. This is principally due to the larger rollers, but possibly it may also be partly due to the fact that the feed roller had deep grooves running lengthwise and this made the mill grip the cane more securely and prevented loss of time in feeding. The extraction was also somewhat greater, which gave a saving of something between 100 and 200lbs. of sugar, or about 8 maunds of jaggory per acre. The draft, which was nearly half as much again as that required for the local mill, is almost completely compensated for by the more rapid milling. In the local mill it was difficult to mill four canes at the time, but in the imported mill this could be done easily. It is rather surprising that milling of cane with the local mill is considered rather hard work for bullocks, especially when only two canes are

being fed at the time and the rollers are not set as close as they were in these tests; for with two canes the average draft required in the tests here was only about 65lbs. The Nahan Mill cost Rs. 161 landed here; of this Rs. 59 was freight.

50. *Composition of begasse.*—As a general rule the begasse (the refuse cane left after milling) is used as fuel in sugar-boiling. To form some idea of its manurial value a number of samples of air-dried begasses were analysed. Below in Table No. VIII are given the results of these analyses.

TABLE VIII.

Composition of begasse (refuse cane) after being dried in air.

Number	Nitrogen	Lime	Potash	Phosphoric acid	Moisture
412	0·24	0·101	0·31	0·166	6·57
424	0·34	0·103	0·30	0·160	7·29
428	0·23	0·100	0·19	0·130	7·76
431	0·16	0·085	0·185	0·120	6·47
441	0·24	0·140	0·23	0·130	...
451	0·23	0·120	0·28	0·145	...
Average ...	0·24	0·108	0·246	0·142	...
Per acre (Begasse representing 20 tons of cane).	lbs. 11·41	lbs. 5·13	lbs. 11·69	lbs. 6·75	...

It will be seen from the above table that the manurial value of the begasse is very little indeed. At current market prices fertilizers containing the same amount of plant food as is contained in the begasse obtained rfom an acre of cane (calculating that an acre produces 20 tons of cane) could be bought for Rs. 8 per acre. Incidentally these analyses of begasse give us some

indication of the amount of plant food removed per acre, for probably a large portion of plant food actually removed is contained in the begasse. Analyses of the juice and the leaves and tops will be made next year. But, unless these substances contain much larger quantities of plant food than is expected, sugar-cane will probably form a striking illustration of the fact that the manurial requirements of a plant cannot be gauged by the amount of plant food stored up in its tissues.

51. *Pot-cultures and a study of the soil used for the same.*—As a large part of the pot-culture house was put up by the servants of the Department, who could only work at it when other work was not too pressing, the house was not ready for working in until the close of the official year. A set of experiments has been begun to study the factors which affect the availability of bone meal. On one of the Mysore coffee estates on which milled bone was applied in pits more than 28 years ago, it still remains and is occasionally being dug up. On another estate in Coorg, where bone meal is applied on the surface and is in the course of a short time covered by leaves, the bone disappears in a very short time and little of it can be found ten months after it has been applied. In both cases the meal was not fine and contained pieces an inch or more in length. A *possible* cause for this difference is that either the micro-organisms which cause the decomposition of the leaves into mould may help in the decomposition of the bone, or that the carbonic acid produced by the decomposing vegetable matter may have helped to dissolve the bones. To see if the organic matter had anything to do with the decomposition of the bone and to test the availability of bone meal under tropical conditions a set of pot-culture experiments has been started. In these, bone meal of two different grades of fineness has been applied in different ways, (*a*) mixed with the top two inches of soil, (*b*) mixed with the top two inches of soil and covered with vegetable matter,

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451	0·23	0·120	0·28	0·145	...
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51. *Pot-cultures and a study of the soil used for the same.*—As a large part of the pot-culture house was put up by the servants of the Department, who could only work at it when other work was not too pressing, the house was not ready for working in until the close of the official year. A set of experiments has been begun to study the factors which affect the availability of bone meal. On one of the Mysore coffee estates on which milled bone was applied in pits more than 28 years ago, it still remains and is occasionally being dug up. On another estate in Coorg, where bone meal is applied on the surface and is in the course of a short time covered by leaves, the bone disappears in a very short time and little of it can be found ten months after it has been applied. In both cases the meal was not fine and contained pieces an inch or more in length. A *possible* cause for this difference is that either the micro-organisms which cause the decomposition of the leaves into mould may help in the decomposition of the bone, or that the carbonic acid produced by the decomposing vegetable matter may have helped to dissolve the bones. To see if the organic matter had anything to do with the decomposition of the bone and to test the availability of bone meal under tropical conditions a set of pot-culture experiments has been started. In these, bone meal of two different grades of fineness has been applied in different ways, (*a*) mixed with the top two inches of soil, (*b*) mixed with the top two inches of soil and covered with vegetable matter,

and (*c*) applied on the surface and covered with vegetable matter. The ordinary precautions were taken to have pots in which the soil was unmanured and some in which only nitrogen and potash had been supplied. Provision to study the effect of the mulch of organic matter applied on the surface of the pots was also made. The crop used is ragi.

52. Before beginning these experiments it was necessary to study the soil intended to be used in them, to find out how closely it ought to be packed in the pots and what percentage of water in the soil was likely to give satisfactory results. For it is not only sufficient in pot experiments to have the same kind of soil in all the pots, but to have it compressed uniformly and to have the same percentage of water present in each pot. The water-holding power of the soil used is 31·4% and its specific gravity at 32° C is 2·677. Soil containing 10% of water appeared, when handling it, to have about the right amount of moisture for the growth of ragi. To get some further insight into the quantity of water which it would probably be found necessary to add to the soil used for these experiments, a glass cylinder 16 inches long was filled with this soil as tightly as it was thought necessary to pack the soil in the pots and sufficient water was added to make the total moisture of the soil in this cylinder up to 10%. This cylinder was open at the top and bottom, but to prevent evaporation was covered with a glass plate. The cylinder with the soil and water was weighed just after the water had been poured on, and to make sure no water had been lost by evaporation, was again weighed just before the experiments were completed. The following figures show the rapidity with which the water entered the soil :—

Number of hours after adding water	The water had penetrated
3	$8\frac{1}{4}$ inches.
20	$10\frac{1}{4}$ „
48	$10\frac{7}{8}$ „
96	$11\frac{1}{4}$ „
120	$11\frac{1}{2}$ „

After standing five days it was very difficult to detect by the difference in colour of the soil the depth to which the water had penetrated. But apparently it sank no further than $11\frac{1}{2}$ inches. The following table shows the percentage of moisture of the soil in the cylinder at the various depths a week after the water had been added :—

TABLE IX.

Showing percentage of water at various depths.

1st inch ...	13·54 per cent of water	9th inch ...	10·71 per cent of water
2nd „ ...	12·13 „	10th „ ...	9·91 „
3rd „ ...	12.41 „	11th „ ...	8·95 „
4th „ ...	12·28 „	12th „ ...	5·62 „
5th „ ...	12·70 „	13th „	
6th „ ...	12·41 „	To bottom of	
7th „ ...	11·84 „	cylinder ...	1·49 „
8th „ ...	11·58 „		

In taking the samples out of the cylinders and in weighing, nearly $\frac{3}{4}$% of the moisture was lost, the total moisture being, instead of 10%, only 9·3% on the average. From this it is evident that if only water sufficient to give the soil 10% of water is added, the bottom layers of soil will not get the water they require, and as in nature the water is supplied from the surface, it was considered necessary to supply enough water to the pots to reach the bottom layers of soil. For this purpose 12% of water was necessary for this particular soil.

53. To form some idea of the extents to which the soil ought to be compressed, samples were taken from a plot of ground in the Laboratory compound on which ground-nuts were growing and which had been ploughed about two months before. In Table No. X are given the space actually occupied by the soil particles and the moisture of the samples at various depths down to $5\frac{1}{2}$ feet.

TABLE X.

Depth at which sample was taken	Space occupied by soil particles. %	Moisture %
Surface to 6″ ...	62·53	5·37
6″ „ 1′ ...	53·17	9·03
1′ „ 1′-3″ ...	66·95	9·64
1′-3″ „ 1′-6″ ...	65·14	10·32
1′-6″ „ 1′-9″ ...	66·43	10·47
1′-9″ „ 2′ ...	65·97	10·67
2′-3″ „ 2′-6″ ...	63·88	10·62
2′-6″ „ 2′-9″ ...	65·13	11·08
2′-9″ „ 3′ ...	64·50	11·64
3′ „ 3′-3″ ...	65·23	11·50
3′-3″ „ 3′-6″ ...	63·78	11·55
3′-6″ „ 3′-9″ ...	60·60	11·37
3′-9″ „ 4′ ...	62·53	11·65
4′ „ 4′-3″ ...	63·39	11·80
4′-3″ „ 4′-6″ ...	64·28	11·64
4′-6″ „ 4′-9″ ...	66·83	11·71
4′-9″ „ 5′ ...	63·52	10·73
5′ „ 5′-3″ ...	62·66	11·33
5′-3″ „ 5′-6″ ...	61·31	12·02
Average below 1 foot ...	64·24	11·16

Apparently the top 6 inches of soil had become almost as compact again as the subsoil; but the next 6 inches were much softer than the top (the soil had been dug about 1 foot deep) and these second 6 inches of soil were taken as the standard to which to compress the soil in the pots. Other tests had also shown that soil compressed to such an extent (that the soil particles actually occupied 53% of the space) would be about as compact as a field would be after it had been ploughed for a short time. The reason for giving the above table in full is to show the gradual and almost constant increase in the percentage of water from the surface

down. These samples were taken in the hot weather, and the results appear to indicate, when taken in conjunction with Table No. IX, page 27, that this soil tends to retain 12 or 13% of water under ordinary circumstances. Some other tests made in regard to the capillarity of the soil in question will be reported at some later date.

54. *Fertilizers.* —At the suggestion of the Department of Agriculture of Madras the matter of the standardisation of fertilizers was brought up at the last meeting of the Board of Agriculture at Pusa, but a full discussion of that subject was deferred for a year. To obtain further information about the fertilizers offered for sale in Southern India an attempt was made to collect and analyse samples of all fertilizers on the market in Southern India. Mr. Benson, the then Deputy Director of Agriculture of Madras, undertook the collection of the samples and forwarded them to the Laboratory of this Department for analysis. In all 47 mixed or "patent" fertilizers and 86 samples of ordinary fertilizers (such as oil cakes, bone meals, sulphate of potash) were received. Mixed fertilizers are no doubt those which lend themselves most easily to fraudulent practices, and are those in which a guarantee as to quality is most urgently required. But this particular set of samples was supplied directly by a large and well-known firm, so that adulteration was out of the question, and as neither the price of the fertilizers nor any guarantee as to their composition accompanied these samples, it would have been impossible to detect adulteration if it had been practised. Probably the price charged for these fertilizers and a guarantee as to their composition could have been obtained. But as there was not sufficient time to undertake all the analyses, the mixed samples were not analysed this year.

55. In Tables Nos. XI to XV, on pages 30 and 31, 35, 39, 42 and 43 and 46 and 47 are given the results of the analyses of these fertilizers for the sake of comparison; the averages, maxima and minima, of the most important of the fertilizers analysed in previous years are also given.

TABLE

Results of analyses of oil

No.	Substance	Results of previous year's nitrogen			Nitrogen
		Average	Maximum	Minimum	
1	2	3	4	5	6
	White Castor	6·37	8·69	4·53	...
365	Do	...	...	...	4·25
308	Do	...	...	...	4·95
286	Do	...	..	...	5·26
299	Do	...	...	...	5·46
344	Do	...	..	...	6·22
330	Do	..	..	...	6·23
319	Black Castor	...	...	...	3·99
331	Do	...	...	..	4·22
317	Do	...	...	...	4·33
358	Do	...	..	...	4·64
363	Do	..	...	...	4·74
307	Do	...	..	..	4·78
300	Do	...	...	..	4·89
	Hongay (Pongamia glabra)...	3·83	4·01	3·59	...
360	Do	...	...	..	3·37
329	Do	...	...	...	3·92
301	Do	...	...	...	4·03
287	Do	...	...	.	4·05
334	Do	...	...	...	4·05
343	Do	...	..	...	4·11
	Neem (Melia Azadirachta) ...	4·86	5·99	4·12	...
298	Do	..	...	...	3·89
335	Do	..	...	..	5·11
288	Do	...	...	...	5·38
	Ippe (Bassia latifolia) ...	2·97	4·14	1·80	...
	Kurdi (Carthamus tinctorius)	5·70	8·30	3·22	...
56	Do	...	...	...	2·58
285	Ground-nut	...	...	...	7·89
262	Till	...	..	...	4·93
	Dried Blood	...	11·55	10·40	...
304	Do	..	...	..	11·51

XI.

cakes and dried blood.

Results of 1905-06—(*concld.*)					Price per ton	Value per unit of nitrogen, making no allowance for potash or phosphoric acid
Loss on ignition after drying	Phosphoric acid	Potash	Insoluble residue	Source		
7	8	9	10	11	12	13
					Rs. a. p.	Rs. a. p.
...	...	...	...	...	.....	.....
...	...	...	..	Madras West Coast.	60 0 0	14 1 1
...	...	...	...	Do ..	60 0 0	12 1 11
86·99	1·88	0·96	2·82	Do East Coast ..	72 0 0	13 11 0
...	...	...	...	Madras ...	77 8 0	14 3 1
...		..	..	Mysore ...	66 0 0	10 15 2
...	...	...	...	Do ...	57 8 0	9 2 5
...	1·86	...	10·64	Do ...	. ...	.....
...	...	...	...	Do ...	48 0 0	11 6 0
...	...	...	...	Do ...	50 0 0	11 8 9
...	...	...	..	Madras West Coast	57 8 0	12 6 3
..	...	...	...	Do ...	50 0 0	10 8 9
...	..	..	...	Madras ..	57 8 0	12 0 6
...	...	...	...	Do ...	65 0 0	13 4 8
...	...	...	..	...	... ..	.. ..
...	...	...	..	Madras West Coast	47 8 0	14 1 6
...	...	...	..	Mysore ...	40 0 0	10 3 3
88·04	0·88	..	1·52	Madras ...	57 8 0	14 4 3
85·91	1·50	1·06	2·95	Do East Coast...	50 0 0	12 5 6
...	...	...	...	Mysore ...	40 0 0	9 15 10
...	...	...	...	Do ...	45 0 0	10 15 2
...	...	..	...	.....	.....	.....
83·20	0·92	...	4·98	Madras ...	62 8 0	16 1 1
...	..	..	...	Mysore ...	45 0 0	8 12 10
82·08	1·29	...	5·34	Madras East Coast	50 0 0	9 4 8
...	..	...	...	... ..	... ..	.....
...	...	...	..	.....	.....	.....
94·98	1·37	0·80	1·39	Madras ...	.....	.. .
88·33	1·60	1·20	1·77	Do East Coast...	70 0 0	8 13 11
...	...	...	...	.....	.....	.....
...	...	...	...	.....	. ...	.....
81·48	0·42	...	5·81	Madras ...	115 0 0	10 0 0

56. This year's analyses of oil cakes again exemplify the fact that there is a very considerable difference in the quality of oil cakes.

57. *White Castor* varies from 4·25% nitrogen content, to 6·23%. None of these appear to be free from adulteration, but the general principle that they vary with the district from which they come, again holds good, the West Coast of Madras having white castor decidedly poorer in quality than Mysore.

58. *Black Castor* has this year a fairly uniform composition, the maximum being only about 15% above the minimum in quality.

59. *In Hongay and Neem* the variations are a little greater than they have been heretofore, the minima being lower and the maxima being higher than have been noticed before, in Neem there being a difference of a little over 38% between the poonac of best and poorest quality. But in neither of these is the variation anything like as great as in White Castor, Ippe and Kurdi. In these three the difference in quality, found up to date, is over 100%, and is principally due to difference in variety,but partly to adulteration.

60. Special attention is called to the last column in the above table, which gives the price per *unit of nitrogen* charged for each of the fertilizers. The price per unit of nitrogen is obtained by dividing the price of the fertilizer per ton by the figure representing the percentage of nitrogen. If the fertilizer contains small quantities of plant food other than nitrogen, the value of these should be deducted from the price of the fertilizer before dividing it by the figure representing the percentage of nitrogen. All oil cakes contain a small percentage of both phosphoric acid and potash. But the value of these is so small compared with the nitrogen contained in oil cakes that these substances (potash and phosphoric acid) are not always determined, and the entire cost of the oil cake is debited to the nitrogen

contained in it. Sometimes the amount of phosphoric acid which, as will be noted, varies in the above table from 0·88% to 1·88%, is determined, and if allowance is to be made for this we may consider this phosphoric acid to be worth about Rs. 3 per unit. To determine the unit value of nitrogen in oil cakes when allowing for the phosphoric acid, multiply the figure representing the percentage of phosphoric acid by 3 and deduct the result from the price in rupees of the oil cake in question and then divide the remainder by the figure representing the percentage of nitrogen. Of course, the organic matter in the oil cakes is as such of some value provided it does not contain too much fat, but this does not possess a commercial value.

61. By comparing the figures in column 13 of the above table it will be noticed that sample No. 298 is nearly twice as expensive per unit of nitrogen as sample No. 335, and an average sample of safflower cake at Rs. 45 per ton (the price at which it is quoted now) would be cheaper still (being about Rs. 8 per unit).

62. *Milled fish.*—The results of this year's analyses reduce the already very low minimum of nitrogen found in milled fish in previous years. Sample No. 77z was offered to a West Coast firm on a guarantee, but as it did not come up to that guarantee it was declined. All the samples analysed this year contain an excessively large proportion of sand. The average of the insoluble matter found in the samples analysed some years ago was a little less than 6%. This year's average amounts to more than six times this quantity (39·56). Such excessive adulteration reduces very materially the value of milled fish as a manure.

63. As will be seen by comparing the results given in the table (p. 35) a marked variation again exists in the composition of the samples of milled fish both in their nitrogen content and in the phosphoric acid, and, although this difference is not as marked as it has been

in previous years, it is very considerable. There is also a very striking difference in the cost per unit of both nitrogen and phosphoric acid as given in columns 18 and 19 in the table on page 35. To determine the cost of the units of nitrogen and phosphoric acid in these manures it has been assumed that a pound of nitrogen is four times as valuable as a pound of phosphoric acid.

64. *Prawn skins.*—The only sample received this year is badly adulterated with sand, being mixed with nearly its own weight of that material. The only other sample analysed in this Laboratory was received some years ago. It had 4·47 per cent sand and was fully 50 per cent more valuable than the sample analysed this year. Evidently the agents offering the prawn skins (of which I received a sample this year) considered the fertilizer to be very much more valuable than it really is. At any rate they charged per unit of nitrogen and phosphoric acid more than double the price in this fertilizer than these ingredients can be bought for in bone meal. These prawn skins were said to contain 7 per cent of nitrogen and 7 per cent of phosphoric acid, quantities very much above those actually found in the sample received.

65. *Bone meal.*—This is undoubtedly a fertilizer in which both the nitrogen and the phosphoric acid are sold at a very low price per unit in India. It has always been admitted that the nitrogen in bone meal is in an available form. But as to the value of the phosphoric acid contained in this fertilizer, there is some difference of opinion. Experiments conducted by some of the leading German Agricultural Chemists place the value at little above that of mineral phosphates, which are, when in the undissolved condition, practically valueless as fertlizers, while the experiments conducted in Japan give it a very much higher value. Observations made in India also differ materially. As stated in another part of this report (para 51, page 25) a sample of coarse bone meal applied on the surface under a covering of leaves disappeared in less than a year. While another sample of coarse bone meal buried deeply was dug up after 28 years. The composition of the latter (No. 326) is given in the table on page 35. As will be noticed, this sample still contains nearly half its percentage of nitrogen. Evidently neither the phosphoric acid nor the nitrogen is readily available when the bone is buried deeply in the soil, and the whole question needs further

investigation. This investigation is all the more desirable as the ingredients of plant food contained in bone can be bought comparatively cheaply in that form, and as owing to the high percentage of iron and the very low percentage of lime in the Mysore soils, superphosphates may not give relatively as good results in Mysore as have been obtained elsewhere.

66. *Bone char.*—This substance, which is a waste product from the sugar refineries, is generally considered to be very inert. It has been tried on coffee estates and has been dug up (though originally it was buried only a few inches) after seven or eight years in very much the same condition as it was put in. Even at Rs. 1-7-1 per unit, or even half that price, it is not likely to prove a valuable fertilizer. In Europe it is now principally used for making superphosphates. But to use it at a profit for this purpose necessitates a cheap supply of sulphuric acid.

67. *Ammonium salts and nitrates.*—It is only necessary to glance at the price per unit of nitrogen in column 11 of the following Table No. XIII to realise the great variations which exist in the prices charged for these "artificial" fertilizers. The chief reason for this is no doubt that, apart from saltpetre (in which both the nitrogen and potash are quoted at a low price) there is as yet little demand for these fertilizers; and relatively high prices are charged by some firms to compensate them for having to keep these fertilizers in stock a considerable time. No. 272 in the table below is a good quality of sulphate of ammonia, and in it the nitrogen is quoted at a lower figure than is charged for it in the majority of oil cakes given in Table No. XI of this report, and at that price it ought to find a ready sale. No. 338 is a nitrate of soda which has been in stock for a number of years and of which very little has been sold during that time. But the price charged for it is so high that unless reduced it is likely to remain in stock very much longer, notwithstanding that it is a "Chili

Saltpetre" of excellent quality, being over 97% pure. In calculating the price per unit of potash and nitrogen in saltpetres the nitrogen has been considered to be three and a half times more valuable than the potash.

TABLE XIII.

Composition of ammonia salts and nitrates.

No.	Substance	Moisture	Insoluble residue	Nitrogen		Potash		Received from	Price	Price per unit of	
				Found	Guarantee	Found	Guarantee			Nitrogen	Potash
1	2	3	4	5	6	7	8	9	10	11	12
		%	%	%	%	%	%		Rs.	Rs. a. p.	Rs. a. p.
272	Sulphate of ammonia ...	..		20·60	...	...	..	Madras East Coast.	225	10 15 3	.....
289	Do ...	...	0·14	20·49	20·00	...	..	Madras ...	330	16 4 1	... ..
312	Do ...	0·17	1·78	20·13	...	. .	...	Do ...	315	15 10 4	.....
291	Nitrate of soda (Chili saltpetre)	0·20	0·12	15·38	15·00	...	...	Madras ...	255	16 9 3	.....
338	Do ...	0·17	0·34	16·08	...	...	...	Mysore ...	300	8 10 6	.....
353	Do ...	0·66	0·16	15·75	15·6	...	..	Bombay...	..	.....	.....
293a	Refined saltpetre (nitrate of potash)	0·05	0·08	13·61	...	46·93	..	Madras ...	...	.....	.....
294	Refined saltpetre (nitrate of potash)	0·60	0·23	11·62	8—10	40·46	35—50	Madras ...	205	8 15 7	2 9 0
66	Do ...	3·00	...	9·83	..	38·36	...	Madras ..	...	.....	.....
337	Saltpetre (nitrate of potash) ..	0·46	0·44	10·19	...	35·78	..	Mysore ...	125	6 1 11	1 12 0
295	Crude saltpetre ...	1·25	0·42	7·48	3—4	26·88	18—25	Madras ...	105	6 14 10	1 15 8
	Average of crude saltpetre analysed in former years ...	6·18	...	3·62	...	17·90	...	...	...	.....	.....

Acc. No. 9958.

68. *Phosphatic fertilizers.* —Of these the first two in Table No. XIV, pages 42 and 43 are "mineral phosphates," which have not given so far valuable results when applied in an "undissolved" condition. No. 204 was very finely ground and was evidently intended for direct application to the soil. It has been referred to on page 47 of last year's report. No. 284 was not nearly so finely ground and is evidently only intended to be used by the manufacturer of superphosphates.

69. *Basic slag* is a by-product in the manufacture of steel which, although it contains a high percentage of lime, is comparatively easily available and is ranked next to superphosphates in this respect. It is free from the objections which may possibly be raised against superphosphates, that owing to the high percentage of iron in the Mysore soils there may be some danger of the phosphoric acid of superphosphates becoming rapidly insoluble, and that owing to the acidity of superphosphates they may have some injurious actions on soils so poor in lime as those of Mysore. Whether superphosphates actually have these drawbacks, has not yet been determined. But whether they exist or not so far as superphosphates are concerned, they certainly do not apply to basic slag. In basic slag the fineness of the material is a very important factor. The more finely it is ground, other things being equal, the more readily available it is.

70. *Superphosphates.* —Of those, the composition of which are given in the table on pages 42 and 43 No. 72, No. 73 and No. 76 are of Indian manufacture. All the samples presented a good appearance. In No. 73 nearly all the phosphoric acid has been made water-soluble, while in No. 72 and No. 76 a considerable quantity remained insoluble in water. And in No. 76 very little of that which was insoluble in water was soluble in a neutral solution of citrate of ammonia. No doubt when sulphuric acid can be produced cheaply enough in India, superphosphates will also be manufactured on a much larger scale than at present. No. 355 is a so-called double

superphosphate specially made in Europe for export, to reduce freight charges, by increasing the percentage of phosphoric acid.

71. *Bone superphosphates.*—The last four samples on the list were prepared by treating bone meal with various quantities of acid sulphate of potash in solution, as recommended in para 63, page 46 of my report of last year. These fertilizers contain nitrogen, potash and phosphoric acid and are therefore, in one sense of the word, complete fertilizers. They are not, however, well balanced, as the percentage of nitrogen is too small, being on an average only about one-sixth that of the phosphoric acid. The potash varies with the quantity of acid sulphate used. A certain proportion of the phosphoric acid in the bone is made water-soluble, which of course increases its value. But it requires practical tests in the Pot-culture house to determine if the acid nature of the bisulphate of potash has been sufficiently reduced by this treatment to make it harmless. If such is not the case, the reaction which has begun by simply allowing the bones to remain in contact with the solution of acid sulphate of potash could, no doubt, be increased by heating the mixture, and possibly some practical way may be devised for doing this.

TABLE

Composition of phosphatic fertilizers

No.	Substance	Water	Insoluble residue	Iron and aluminium oxides	Potash	Phosphoric	
						Water soluble	
						Found	Guaranteed
1	2	3	4	5	6	7	8
						%	%
204	Trichi phosphate ...	...	..	...	...	...	...
284	Christmas Island phosphate ...	0·37	0·06	...	...	...	...
293	Basic slag ...	0·285	9·25	...	...	...	.
311	Do ..	0·228	10·46	...	...	...	...
356	Do ...	.	11·12	...	...	...	...
359	Do ...	0·175	8·10	16·42	...	...	...
283	Superphosphate ...	6·60	...	1·71	...	16·37	...
292	Do ...	7·04	...	..	...	21·07	...
314	Do ...	10·79	...	...	...	17·60	...
354	Do ...	...	..	...	...	17·17	...
355	Do ...	...	...	...	...	37·27	42—44
72	Do ...	...	...	...	..	11·71	...
73	Do ...	...	...	...	..	13·67	...
76	Do ...	...	...	...	...	12·04	...
305	Bone superphosphate and potash	2·76	...	...	...	2·29	...
81	Do ..	3·61	...	...	9·76	2·92	...
82	Do ...	...	...	...	4·07	0·20	...

XIV.

other than bone meal, dried fish, etc.

acid				Passed through standard sieve 100 meshes to the inch		Price	Price per unit of phosphoric acid	
Citrate soluble		Total						
Found	Guaranteed	Found	Guaranteed	Found	Guaranteed		Available	Total
9	10	11	12	13	14	15	16	17
%	%	%	%	%	%	Rs.	Rs. a. p.	Rs. a. p.
0·38	...	25·51	...	99·00	...	...	.....	.....
...	...	39·13	...	51·59	...	100	.....	.....
..	...	15·95	16—18	83·63	...	100	.....	6 4 8
...	...	14·20	..	89·86	...	95	.....	6 11 0
...	13·41	14·40	14·00	90·10	81·6	...	.....	.....
...	...	20·01	...	87·32	...	70	.....	3 7 11
1·66	...	18·13	...	..	...	108¾	6 0 6	.....
...	...	23·38	20—23	...	...	150	7 1 11	.....
3·69	..	21·45	...	...	...	130	6 1 8	.....
...	...	20·49	15—16	...	...	...	.....	.....
...	3·66	42·82	44—48	...	...	...	.....	.....
...	...	18·12	...	...	...	...	.....	.....
...	...	14·00	...	...	...	...	.....	.....
0·68	...	29·35	...	...	...	..	.....	.....
9·79	...	15·66	...	...	...	80	.....	.....
8·69	...	17·55	...	...	..	...	.....	.....
8·16	...	19·20	...	...	...	...	.....	.....

72. *Potash fertilizers.*—Among these should be included ashes and *saltpetre.* The latter are therefore again included in this table, although they have already been given in Table No. XIII. In column 10 in Table No. XV, page 47, is given the cost price of a unit of potash in saltpetres on the assumption that they are bought simply for the sake of the potash contained in them. The figures given there show that even if the nitrogen is disregarded, the potash is no more expensive than in the form of muriate or sulphate of potash.

73. *Kainites.*—In these the unit of potash is very expensive, running up to Rs. 5-13-5 per unit, a price more than 50% above that at which potash could be bought in other fertilizers. But even at that high figure there is little profit in it for the firm which imported that particular shipment on account of the very limited sales they have had. But it is absolutely useless to import Kainite or any other fertilizer if after it arrives such a prohibitive price has to be charged for it that it would be foolish for any one to buy it.

74. *Sulphate of potash.*—Included under this head is a fertilizer just placed on the market called "Stanes' Sulphate of Potash." It is sold at a price decidedly lower than the imported sulphate, and if the supply is constant and the quality and price remain in the same relation with the imported fertilizer as they stand now, there ought to be a good demand for this fertilizer in time. Samples No. 75 and No. 79 are fertilizers having a decidedly acid reaction, and cannot therefore be recommended on soils as poor in lime as those of Mysore until after they have been thoroughly tested and found to have no injurious results.

75. *Ashes.*—In last year's report, page 48, reference was made to *Lantana ash*, and in their review of last year's report Government directed that a sample of Lantana ash be analysed. The sample of Lantana ash was prepared some years ago from Lantana growing in this compound. As stated in Table No. XV, pages 46 and 47,

it contained 13·26% of water-soluble potash. The total potash soluble in acids was 15·74% and the phosphoric acid 4·50 %. This sample of ash contains therefore about the same quantity of water-soluble potash as Kainite, one sample of which is quoted at Rs. 80 per ton. But, as pointed out above, the price of potash in Kainite is very high. But at the ordinary market price of potash, this sample of Lantana ash would still be worth Rs. 46 per ton for the potash it contains. The phosphoric acid would be worth a little over Rs. 13, making the total value of the ash nearly Rs. 60. Unfortunately the green Lantana stem, branches and leaves contain only about 2% of ash. But, notwithstanding this, the high value as a fertilizer these ashes possess ought to help very materially in keeping down Lantana in districts where there is a demand for a potash fertilizer. *Paddy husk ashes* are generally considered to be of very little value. But they are by no means the poorest sample of ashes analysed in this Laboratory, as they contain 1·57% of water-soluble potash. And the fact that paddy husks contain a high percentage of ash (those analysed here contained 21·6%) should make them comparatively plentiful where paddy husks are used as fuel. In Table XI on page 49 of last year's report are given a number of analyses of wood ashes which show the great variations which exist in their composition. From that table the composition of Bratty ashes and bamboo ashes have been borrowed for Table No. XV given below. The maximum and minimum amounts of water-soluble potash found in mixed wood ashes analysed in former years in this Laboratory have also been included.

TABLE

Corrected and brought up

Showing composition of

No.	Substance	Water	Insoluble residue	Potash, water-soluble	
				Found	Guaranteed
1	2	3	4	5	6
		%	%	%	%
75	Double sulphate of potash and soda	0·12	1·48	31·52	...
79	Do	...	2·30	32·38	..
83	Stanes' sulphate of potash ...	..	8·23	45·13	40·00
282	Sulphate of potash... ...	0·10	0·45	51·33	...
290	Do	..	...	...	51·00
313	Do	0·37	0·64	44·06	..
352	Do	0·18	0·77	46·58	48·60
281	Muriate of potash	0·18	0·30	53·82	...
315	Do	0·08	0·59	58·63	..
336	Do	0·09	0·23	51·92	51·40
351	Do	0·42	0·16	54·88	50·50
280	Kainite	1·28	1·14	12·25	..
339	Do	0·32	0·88	13·70	...
350	Do	2·68	1·09	13·35	12·40
294	Saltpetre	0·60	0·23	40·46	..
295	Do	1·25	0·42	26·88	...
337	Do	0·46	0·44	35·78	...
	Mixed wood ashes, maximum of former analyses ...	...	...	2·32	...
	Mixed wood ashes, minimum of former analyses ...	..	...	0·40	..
250	Lantana ashes	...	...	13·26	...
	Paddy husks	...	...	1·57	...
	Bamboo ashes	...	..	5·40	...
	Bratty „	..	...	2·53	..

XV.

to date January 25th, 1907.

Potash Fertilizers.

Chlorine	Sulphuric acid	Received from	Price per ton	Cost per unit of potash	
				Considering potash only	After deducting nitrogen
7	7a	8	9	10	11
%	%		Rs.	Rs. a. p.	Rs. a. p.
0·16	..	Madras ..	...	.....	.....
0·88	...	Do ...	..	.....	.....
...	...	Do ...	120	2 10 6	.....
..	44·43	Madras East Coast	197½	3 13 5	.....
...	...	Madras ...	250	.....	.....
...	44·23	Do ...	235	5 5 4	.....
..	43·97	Bombay ...	190	4 1 3	.....
48·37	...	Madras East Coast	168¾	3 2 2	.....
48·03	...	Madras ...	210	3 9 4	.....
49·39	...	Mysore ...	260	5 0 1	.....
48·57	...	Bombay ...	170	3 1 7	.....
...	17·40	Madras East Coast	77½	5 14 8	.....
...	17·21	Mysore ...	80	5 13 5	.....
...	15·09	Bombay ...	70	5 3 11	.....
...	...	Madras ...	205	5 1 1	2 9 0
...	...	Do ...	105	3 14 6	1 15 8
...	...	Mysore ...	125	3 7 11	1 12 0
...	...	.....	...	.....	.....
..	...	.....	...	.....	.....
..	..	Mysore ...	...	.....	.....
..	...	Do ...	...	.....	.....
..	...	Coorg ...	...	.....	.....
..	...	Mysore ...	...	.....	.....

Insect Pests and Plant Diseases.

There have been numerous inquiries regarding remedies for insect pests and plant diseases. Borers of various kinds have been as numerous as ever, and the sugar-cane borers have been more numerous than I have seen them before. The boll worm and "red bug" have been noticed very much, the latter especially, on Caravonica cotton. An Epilachne (a lady-bird) has been reported as especially injurious to potatoes. The caterpillar of a moth (Ophiusa melicerte) has been reported from various districts as affecting castor very badly, and the Kumbli Hula has been particularly destructive in a few places. But until Mr. Coleman arrives, there is no chance of dealing with these and a large number of other pests in anything but a superficial way. But it is hoped that Mr. Coleman will be ready to join his appointment of Mycologist and Entomologist early in 1907.

A. Lehmann,
Agricultural Chemist.

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DEPARTMENT OF AGRICULTURE,
MYSORE STATE.

EIGHTH ANNUAL REPORT

OF THE

AGRICULTURAL CHEMIST

FOR THE YEAR 1906-1907.

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EIGHTH ANNUAL REPORT OF THE AGRICULTURAL CHEMIST

FOR THE YEAR 1906-07.

PART II.

18. Part I comprising paragraphs one to seventeen is not intended for publication, as it contains nothing of general interest.

SUGAR CANE.

19. *Object of the year's work.*—The chief object of this year's work with sugar cane was to standardise the piece of land selected for sugar cane growing. During the season of growth the very injurious effect of insufficient drainage was strikingly illustrated. The juice of the cane after being weighed and analysed was used for some experiments in sugar making. The result of these was to illustrate that with thorough skimming and liming to neutrality* a very good quality of sugar cane can be produced with comparatively simple contrivances, but that the losses incurred in doing this are very great. Improved machinery is necessary to overcome these. The results and the necessary descriptions are given below.

20. *Description of Plots.*—The wet area of the Experimental Farm at Hebbal contains a strip of land on the southern side which is on an average about one foot above the adjoining strip of land to the north of it. This strip, called Range "A," was divided into seventeen uniformly-shaped plots each having an area of one-tenth of an acre. The plots were nearly four times as long as wide

* The juice is limed to neutrality when, as described on page 13 of the sixth annual report, blue litmus paper is not turned red when dipped into the juice and red litmus paper is not turned blue when dipped into the juice.

and separated from each other by a raised path five links wide running the entire length of the plot. The map is given in the sixth Annual Report. On both sides of this range is a drainage channel. That on the south side was only one foot deep in places. On the southern side is also a small irrigation channel from which each plot can be watered as desired, and beyond the drainage channel but within three feet of it in places is one of the main irrigation channels of the tank. The eastern end and part of the western end of this range are also cut off by a drainage channel from the surrounding land. But in the south-western corner there is no drain.

21. *Influence of drainage on sugar cane.*—Throughout the entire range the southern ends of the plots were decidedly inferior to the remainder of the plots. As stated above, the drain on this side was not as deep as it should have been, being in places only one foot deep. Besides there were two irrigation channels near that side of the range, the one used occasionally when the cane required watering was close up to the plots. The other was separated by the drainage channel, a dam and a narrow strip of land varying in breadth from a few inches to a little over 50 feet. Wherever this strip of land was narrowest and the drain the shallowest the crop on the southern end of the plots was poorest. The cane was planted in rows running lengthwise of the plot, north and south, and at right angles to the long drainage and irrigation channels. To form some idea of the loss sustained by the crop on the southern part of the plots being stunted the centre five rows of plot No. 10 were divided into three equal parts; the weight of cane from the various portions was as follows :—

Section	Weight of cane cut lbs.	Equivalent to tons per acre
Southern	198	$6\frac{3}{4}$
Middle	650	$22\frac{1}{2}$
Northern	904	$31\frac{1}{2}$

With the previous crop of paddy the southern part of these plots had a decidedly better crop than the northern portion. This difference in the crop of sugar cane could not therefore be due to the soil as such, being poorer on the southern end. The suggestion, which might be made, that the heavier crop of paddy had taken more out of the land and that therefore there was not as much available plant food there when the sugar cane was growing, appears improbable when we remember that in the other two ranges of the wet area which had been cropped with paddy this year as well as last year the plots which had given the best crop the first time also gave a crop much above the average the second time. A similar though not quite as striking an illustration of the injurious effect of the proximity of subsoil water on the growth of cane will be noticed by comparing the yield from plots Nos. 1 and 2 with the average of the other plots in Table No. II in the appendix. Plot No. 1 is that nearest to the tank bund. Between it and the bottom of the bund is a road 24 feet wide, a shallow drain about 1½ feet deep, for about two-thirds of its length, a narrow triangular strip of land about 10 feet wide as the base and an irrigation channel. It gave the third highest yield of paddy in its range last year, giving 10 per cent above the average. This year it gave by far the lowest yield in the range, being 33 per cent below the average. This may in a small measure be due to the fact that the cane on this plot did not germinate well and a portion of the plot had to be replanted to ensure an even stand. But the chief reason is, I think, due to the plot being so near to the tank bund and not being drained deep enough. These indications, if confirmed, would prove that it is highly objectionable to grow paddy and sugar cane in adjoining plots unless there is a deep drain separating them.

22. The necessity of having sugar cane lands well drained is generally recognised in all cane sugar exporting countries. And those persons who have seen the effect of shallow drainage on this year's sugar cane crop on the Experimental Farm at Hebbal near Bangalore, and realize that the stunted growth there was really

caused by poor drainage, ought to spare no pains to have their sugar cane lands well drained. This is, I believe, one of the principal things on the cultivation side of the sugar cane industry of Mysore to be learned by its raiyats. In Mysore sugar cane is often treated too much like paddy.

23. *Cultivation.*—The land was ploughed with a light iron plough to a depth of about six inches. Furrows were then ploughed three feet apart (running north and south, the length of the plot) about six inches deep. In these 17 lbs. of black castor cake was evenly spread and mixed with the soil at the bottom of the furrow. One row of whole cane was laid on the loosened bottom of the furrow. These were cut, where necessary, to straighten them and lightly covered with loose earth. Water had been run along the furrows and these allowed to dry sufficiently to prevent puddling of the soil before applying the black castor oil cake. Black castor was used as it was the cheapest manure available at the time, considering quality. It contained 3·99 per cent of nitrogen.* This gave 88 lbs. of nitrogen per acre or nearly 1 ton of oil cake per acre. There were 13 rows of cane in each plot. The cane was planted on the 9th and 10th of March and the first shoots appeared above ground on the 17th of that month. On the 11th of April the stand was fairly even except in plots 1 and 2 where considerable vacancies existed. All the vacancies were replanted on this day, and the first shoots of these were seen nine days later. The cane was earthed up on the 22nd to 25th of June and cultivated twice before that.

24. *Appearance of crop during growth.*—As already said, the southern portion of all the plots, those next to the irrigation channel, were decidedly inferior to that on the north, where a drain 2½ to 3 feet deep carried off the subsoil water. Plots No. 1 and No. 2 were also decidedly inferior in appearance throughout the year. The cane on the northern portion of plots Nos. 6 to 11 appeared to grow more luxuriantly than that on any other part of the field. But before it was full grown some of it lodged.

* Nitrogen is the chief manurial constituent of oil cakes.

25. *Pests.*—A borer entering the cane through its growing point did some damage, especially in the earlier stages of the growth of the one. All stalks which were seen to be affected were cut out and burned. Later on rats and jackals did some damage where they had most cover, especially in the lodged portion.

26. *Harvesting.*—The object of this year's experiment being chiefly to see in how far the various plots would produce the same weight of sugar when the cane grown on them was treated in the same way, it was necessary to cut and crush the cane on every plot as nearly as possible at the same time; for as long as the cane was growing it would probably change in weight and composition from day to day, and the results obtained from a plot harvested at the beginning of a month would not be strictly comparable with those from a plot harvested in the middle or the end of the month; the crop on the one plot would have had two weeks or a month more in which to improve or deteriorate, as the case might be. But as we had only two small bullock mills with which to crush the cane and four ordinary local small pans in which to evaporate the juice, as the juice in each pan had to be weighed, and analysed, the cane, the tops and the begasse represented by the juice in each pan had to be weighed separately and the resultant jaggory (Gur) or massecuite (Rab) to be weighed, and analysed, it was evident that the harvesting would take a very long time. All that could be done was to take a row from each successive plot at a time and thus make the average age at which the cane was cut on each plot the same. The plot on which the first row was cut would be the last to be completely harvested. Similar arrangements had to be made to compensate for the difference there was in the mills. And with all, every precaution had to be taken to prevent samples being mixed up. It would lead too far to describe the methods adopted in detail. It is sufficient to say that this year they worked very satisfactorily indeed, because the cane changed but little in composition during the two months it was being harvested. Whether it changed in weight it is impossible to tell, but probably what change

there was, was slight. But as the cane does not necessarily remain constant in composition and weight nor change uniformly during the harvest season, it is impossible to be sure of being able to satisfactorily compensate for the inaccuracies produced by a protracted harvest season. I confidently hope therefore before long to have the appliances to harvest the entire range of cane plots in a week or two. With appliances permitting the cane of a whole plot being milled at a time and all the juice being evaporated in one vessel, the analytical and other work connected with the harvesting would be reduced to one-tenth of what it now is and the results obtained would be more valuable.

27. *Composition of cane.*—The per cent of juice extracted from the cane was on an average 64·31, and the percentage of begasse,* 32·31. This leaves a wastage of nearly 3·6 per cent caused principally by the loss of juice during milling and evaporation of moisture from the begasse after milling.

28. The solid part of the cane, "the framework" and cell walls which is called mark, was larger this year than in previous years. It constituted 10·41 % on an average of the weight of the cane. It varied from 8·3 % on a part of plot No. 7 to 12 % on a part of plot No. 14. We were unable to find any relation between the percentage of mark and the size of cane or the composition of its juice. But on account of press of work the mark was only determined in a little over 20 % of the samples of cane. The lowest percentage of mark, *viz.*, 8·3 %, was found in the cane which had lodged most and that was where in the early stages the cane had grown most luxuriantly. The lodging was undoubtedly largely due to the small percentage of mark, but that this small percentage of mark was due to the vigorous growth of the cane in its early stages is not necessarily the case, for in previous years we have found a lower percentage of mark than this in cane which did not grow luxuriantly at any time of its growth.

* The refuse cane after it has been crushed.

29. The composition of the juice was fairly uniform notwithstanding that the harvesting season extended over two months. Excluding the badly lodged cane the cane sugar* content varied from 19·25 % to 21·75 % and the glucose* or grape sugar from 1·22 % to 0·18 %. In all cases where the glucose exceeded half a per cent some fermentation had probably taken place. There were several small patches on which the cane had lodged more or less. This cane as well as a large portion of that injured by rats or jackals was harvested together with the sound standing cane, and most of this injured or lodged cane had had a high percentage of glucose, probably due to fermentation. This in itself would account in a large measure for the high percentage of glucose sometimes found in the juice; besides the juice from the injured cane would probably start at once fermentation of the whole lot of juice of which it formed a part. By referring to Table No. II in the appendix it will be seen that the average composition of the juice from the entire field was 20·59 % of sucrose and 0·47 % of glucose. This indicates that the cane is of exceptionally good quality.

30. *Lodged cane.*—The badly lodged portion of cane was harvested separately. It contained 16·1 % of cane sugar and 2·16 % of glucose. Besides this great reduction in quality there was a very material reduction in the total weight of the cane harvested. This lodged portion of cane was at the northern end of the plot where all the plots produced a much better crop than on the southern end. The amount of cane harvested from this patch was equivalent to 4,486 lbs. per plot. The total yield of the plot was 5,262 lbs. But making allowance for the

* The juice of sugar cane contains sucrose and glucose in addition to water, colouring matters, albuminoid substances, ash, acids and a number of other substances not referred to here. Sucrose or cane sugar is absolutely pure ordinary sugar. Thoroughly dry white refined sugar is nearly pure sucrose. Glucose is a name given to a group of other sugars which is not as sweet to the taste, does not crystalize as easily and is simpler in composition than sucrose. It constitutes one of the impurities of sugar, makes the jaggory soft and liable to run in the monsoon and tends to prevent the ordinary sugar from crystalizing or becoming solid.

difference on crop on the northern and southern portions of all the other plots the loss due to the cane having lodged is at least one-third, if not half, of the total weight of cane. And the total weight of sugar produced is far short of being one-half of that which would most likely have been produced if the cane had not lodged.

31. *Comparison of plots.*—As already stated, the cane on plots No. 1 and No. 2 was decidedly poorer in appearance throughout the year than that on the other plots Plot No. 1 produced nearly 25 per cent less sugar than the average of the entire range, and plot No. 2 gave over 22 per cent less than the average. If these continue to yield such poor crops in future they will have to be excluded from the experimental sugar cane area. As already mentioned when speaking about drainage, the paddy produced by these plots in the previous year was up to the average. In fact plot No. 1 was 10 per cent above the average and stood third in yield. With the exception of these two all the plots gave fairly uniform crops. This indicates that the range is probably well suited for experiments with sugar cane. Barring plots No. 7 and No. 2, the variations from the average yield find their extremes in plot No. 7, which is about 7 per cent below the average, and plot No. 13, which is about 13 per cent above the average. Strange to say plot No. 13 which gave the highest yield of sugar cane this year, gave all but the lowest yield of paddy last year. If these results are confirmed they will furnish another illustration that paddy cannot be used as a crop for standardizing plots intended to be used for experiments with sugar canes. Plot No. 14, which gave by far the poorest yield of paddy last year (giving more than 25 per cent below the average) gave slightly above the average weight of cane sugar this year.

32. While in reality the plots, when taken as a whole, gave surprisingly uniform returns, they seemed, when judged by their appearance from the outside, to vary very much indeed. This impression was not much improved when pushing one's way through the standing cane. When only a few rows were left standing on the

centre of each plot and a good view could be had of them from all sides they appeared to be fairly uniform. But even then they did not appear to be nearly as uniform as they were in reality. I wish to draw special attention to this because some experimenters in India have suggested that a sugar cane crop might be judged sufficiently well by the eye. If a reliable assistant cannot be found to weigh the crop the experimentor should, in my opinion, weigh the crop himself, and if a reliable weighing machine cannot be secured it would, in my opinion, be useless to carry on any experiment with cane in which the yield of cane per acre forms any part.

33. *The effect of stunted growth on the composition of cane.*—As already mentioned in para 21 on page 3, when speaking about the effect of imperfect drainage on the growth of cane, one strip of five rows on plot No. 10 was divided into three equal parts. Each was harvested separately. The southern portion produced less than one-fourth of the crop grown on the northern third. The object of reaping these parts separately was chiefly to see what effect the stunted growth had on the composition of the cane. A popular belief is that stunted cane is relatively much the richer. By comparing the composition of the juice from this cane it will be seen that such is certainly not always the case. All the cane was cut and analysed the same day. The following is the result:—

EFFECT OF GROWTH OF CANE ON ITS COMPOSITION.

Description of sample	Weight of cane harvested	Yield per acre	Mark	Juice	
				Sucrose	Glucose
Plot No. 10 rows 5 to 9—	lbs.	Tons	Per cent	Per cent	Per cent
Southern one-third ...	198	6·89	11·43	21·05	·19
Middle one-third ...	650	22·63	10·45	21·65	·38
Northern one-third ...	904	31·47	11·92	20·10	·68

The middle third of these rows is about an average crop. It has a higher cane sugar content and a lower

percentage of mark than either the other two. That in this case the cane which had grown the most vigorously contains the highest per cent of mark is worth noting and is encouraging. It certainly does not support the view that vigorous growth always implies a low mark content. A higher percentage of mark than is required to keep the cane from lodging is of course objectionable. But to have one or two per cent mark more than is actually required is very much better than to have so little mark that the cane lodges. The more vigorous the growth of the cane the more danger there is of the cane lodging on account of the greater weight which has to be supported. If the conditions which favoured a heavy growth of cane also favoured a low or inferior mark formation it would be very discouraging indeed. But the figures obtained this year indicate that such is certainly not always the case.

34. No conclusions can be drawn from the difference in the glucose content. There appears to be an increase in the glucose the heavier the crop. But this is probably due to a larger number of canes having been injured by rats or jackals in the places where the cane stood thickest. Any serious injury to the cane implies of course a reduction of sucrose and increase of glucose. However, the figures do indicate that stunted growth does not necessarily imply a higher sugar content and a higher percentage of mark than would otherwise be the case.

35. *Ripening of cane.*—By referring to Table No. 1 on page 11 of the sixth Annual Report it will be seen that the cane in those experiments was at its best for less than a week, the cane sugar content being nearly 2 per cent lower a month before it reached the maximum and considerably more than 2 per cent below the maximum within a month after it had reached that stage. These were experiments made on samples of six canes each. This year the harvesting season lasted over two months. Below is given a table giving the average composition of all the canes cut in each successive week of the season.

The average composition of the cane cut at different times during the harvest season :—

Week of harvest season.	Sucrose.	Glucose.	Total solid.
1st week	20·25	·41	21·02
2nd ,,	20·76	·33	21·37
3rd ,,	20·89	·44	21·71
4th ,,	20·60	·46	21·51
*5th ,,	...	...	...
6th ,,	...	...	...
7th ,,	20·96	·50	21·88
8th ,,	20·73	·68	21·82
9th ,,	20·49	·67	21·50

36. By comparing the above figures it will be noticed that the cane crop was wonderfully uniform in composition during the entire harvest season. During the first week the cane does not appear to have been quite mature and as the season advanced there was a slight increase in the glucose content. The difference between these results and those recorded in the sixth Annual Report is no doubt due to the fact that in the results of two years ago average canes were selected each time. Those results indicate therefore what takes place in the individual canes. This year's results show what takes place in a field where the stalks are not all of the same age. Some are still improving in composition while others are already deteriorating. The average of a field therefore remains nearly constant for a much longer period of time than the individual canes.

37. *Influence of variety on deteriorations of cane after reaching maturity.*—Varieties differ very materially in the rate with which they deteriorate after maturity. In one of the varieties grown on the Farm the individual canes varied only three-quarters of a percent in their sucrose content during four months' time. During all that time the juice showed a cane sugar content of 21% or more. Another variety remained comparatively constant in quality for six weeks. During that time the individual canes varied about 1% in sucrose (cane sugar)

* During the 5th and 6th week, after beginning the cutting of cane other pressing work had to be done, and no cane was cut.

content, *viz.*, from 19·8% to 21%. Two other varieties deteriorated again as rapidly as the variety experimented with two years ago. Naturally it is desirable to cultivate such varieties, other things being equal, which remain at their best for the longest time.

SUGAR.

38. In para 42, page 21 of my sixth Annual Report, are given some of the reasons why it is necessary that India should produce sugar instead of jaggory or gur or gull if cane growing is to receive the attention it deserves. As stated there the quantity of sugar imported into India in 1903-04 was a little over 106,000 tons. Since then it has been rapidly rising and was last year (1905-06) over 413,000 tons, an increase of nearly 300% in 12 years. In the past two years there has been an increase of 97,000 tons in the imports or an increase of over 30% on the 316,000 tons imported two years ago. And most of this (over 90%) is refined sugar. Last year's imports show an increase in one year of over 19%.

39. To form some idea of the constant increase in the importation of sugar which is going on, I quote the following quinquennial averages of imports in tons and their values for the past 20 years :—

Years	Average import of total sugar Tons	Increase over previous period	Average value per year in lakhs of rupees.	Increase over previous period
	Tons	%		%
1886-91 ...	98,307	...	231	...
1891-96 ...	115,223	17	279	21
1896-01 ...	201,951	75	419	50
1901-06 ...	330,175	63	629	50

Last year's imports amount to nearly 2½ lbs. of sugar for every person living in India, or a little over 3¼ annas per head. When these quantities per individual are compared with the totals of 926,365,440 lbs. and Rs. 7,77,45,199, they appear very insignificant and show that while the total imports are enormous there is every prospect of the present steady advance in the imports

continuing unless something very energetic is done to check them. These constantly increasing imports of refined sugar indicate that there is a strong and growing demand for refined sugar which is not being supplied by the present sugar industry in India. As there are enormous losses in the practice of boiling the sugar cane juice first into jaggory and afterwards refining this, as pointed out in several of my previous reports, it is not surprising that that method which has been practised in India for a considerable period of time is unable to check to any appreciable extent the imports of sugar into India. The only course open is to produce centrifugal sugar directly from the sugar cane juice and not boil it into jaggory first. This course has been advocated by me ever since arriving in India, and every year's work has placed me in a position to urge that course more strongly than in the previous year.

40. "*Hadi's process.*"—The Department of Agriculture of the United Provinces have also studied that problem for some time, and one of their Assistant Directors, Mr. S. M. Hadi, has advocated a system of clarification in which no lime is used, the separation of the scum is assisted by the addition of the mucilaginous extract of the wild "Bhendi" (a hibiscus) and a little bicarbonate of soda and the clarified juice is evaporated by a continuous process in a pan somewhat similar to that used by maple sugar makers in America and sold by manufacturers under the name of "American evaporators." The "Hadi system" is described in detail in Bulletin No. 19 of the Department of Agriculture for the United Provinces. The plant has been exhibited at the Calcutta Exhibition and has attracted a great deal of very favorable attention. It was also exhibited to the members of the Board of Agriculture at Cawnpore and the quality of sugar it turned out has been much admired by all expressing an opinion on the same. To me it appeared, however, that the process must lead to a great loss of cane sugar by inversion into glucose. Mr. Hadi quite realized the advantage of using lime if that could be done without injuring the colour of the sugar produced,

but his experience was that the use of lime invariably affected the colour very injuriously.

41. As the sugar turned out by Mr. Hadi was of exceptionally good quality, and as the loss of sugar due to inversion had never been determined when using this particular process, I determined to try it and check it carefully at the Experimental Farm this year. Instead of the continuous open evaporator used by Mr. Hadi I used the ordinary open pan used by the Mysore raiyat, and instead of the extract of the wild Bhendi I used that of the cultivated variety, *Hibiscus esculentus*, which gives a mucilaginous extract very similar if not identical with that of the wild variety used by Mr. Hadi. However, Mr. Hadi also uses the cultivated variety. In every other detail the process was carried out as in Cawnpore.

42. *Loss by inversion in the "Hadi process."*—As will be seen from Table No. IV in the appendix, there was, on an average, an inversion of over 22 per cent of the sugar into glucose when using the "Hadi process;" while when using the ordinary process, that of fully liming the juice, the loss of cane sugar from inversion was only 6·59 per cent, as given in Table No. V in the appendix. In other words, the use of the "Hadi process" implied that 1,095 lbs. of cane sugar per acre were totally lost when compared with the ordinary process, and that about an equal quantity became irrecoverable from the molasses; in all therefore 2,190 lbs., or nearly one-third of the total sugar in the juice were lost when using this method when the molasses was used for making "second sugars." This at Rs. 2-8-0 per maund of 28 lbs., the price we obtained for the sugar produced this year, amounts to Rs. 195. Mr. Hadi makes no second sugars and boils the molasses from the first sugar into jaggory. If he can sell that at a good figure his loss would be materially reduced. But from a sugar-making standpoint it would still remain unaltered, or rather become worse on that account, because further inversion would take place when boiling the molasses to jaggory. Unfortunately the juice used for these experiments contained a larger percentage of glu-

cose than that used for making the sugar in the ordinary way. Of course that has been taken account of when calculating the loss of sugar by inversion. But it has frequently been noticed that some juices containing a high percentage of glucose to begin with lose more sugar by inversion when boiled down to jaggory (notwithstanding that they are limed in the same way) than other samples of juice containing less glucose to begin with. Why this should be the case has not yet been determined. That it is a fact may be observed by comparing the average loss by inversion given in Table No. III with that in Table No. V. In both the juice was fully limed. But the average percentage of glucose of the juice in Table No. III is considerably lower than that of the juice used, for the results given in Table No. V and the loss from inversion in Table No. III is only about two-thirds of that in Table No. V, being 4·5 per cent in the one and 6·5 per cent in the other. But even making a most liberal allowance for this unfortunate circumstance, the net results will not be materially affected.

43. *Colour of sugars from the "Hadi process" and that made in the ordinary way.* The great advantage claimed for the "Hadi process" is that it will produce a sugar of much lighter colour and much finer and softer grain than when the juice is limed. To test this point the colour of the samples of sugar made by the "Hadi process" were compared with those made in the ordinary way, except that they were washed in the centrifugal with the soapnut decoction used in the Hadi process. The result was that the sugar made in the ordinary way was on the average 6 per cent lighter in colour than that made by the "Hadi process." These tests were made with both the Lovibond tintometer and the Nesler tubes. When both samples were washed with water instead of soapnut decoction there was on the average no difference in colour. Both samples were 30 per cent darker than the average of the sugars boiled from fully limed juice washed in the centrifugal with soapnut decoction. The unwashed sugars were also alike in color, both being 137 per cent darker than the ordinary sugar washed with

soapnut decoction. The sugar produced by the Hadi process had therefore no superiority in colour over that boiled in the ordinary way.

44. *Fineness of grain in sugars.*—The fineness of grain depends principally on the rapidity with which the massecuite or rab is cooled down after boiling and the concentration of the massecuite or rab. The more rapidly it is cooled and the more concentrated the massecuite or rab is the finer the grain. Another factor which affects the size of the grain of sugar is the impurities in the massecuite. The more impurities in the massecuite the less of the sugar will separate out and the finer the grain. The last of these factors is the only one which differs in the two processes, and as the massecuite made by the "Hadi process" is the more impure on account of the large amount of glucose it contains, that process has a tendency to produce a smaller grained sugar. But by stirring the massecuite made in the ordinary way a little longer than is done in the "Hadi process" an equally small grained sugar can be obtained if that is desired. But from a sugar manufacturer's standpoint it is highly desirable to have a large grain or crystal of uniform size. It gives a better outturn of sugar and centrifugals more easily. Besides a large grained sugar generally contains less glucose, in other words, it is purer. If the market demands a small grained sugar it can, I believe, be produced more cheaply by grinding a larger grained sugar than by producing a very fine grained sugar to begin with.

45. *Losses other than by inversion.*—Provided there is no filter press, chief of these losses is the sugar removed in skimming. But no reliable figures are available under that head this year. The chief object this year was to skim as thoroughly as possible, and as time was very pressing the filtration of the skimmings was not carried out with that care it should have been done to get results worth publishing.

46. *Filtration of scums.*—We have not as yet found a simple method of filtering the skimmings which is sufficiently rapid and effective, when the juice is skimmed as

thoroughly as was done this year, to recommend it. There has been, as far we could see this year, no difference in the amounts and consistency of the skimmings in the two processes.

47. *Sugar lost in molasses.*—There was, however, as already mentioned, a difference in the amount of cane sugar lost in the molasses. Although the massecuite (rab) was boiled a little "harder" in the "Hadi process," as is indicated by the glucose ratio of the molasses, there was a considerably larger proportion of undecomposed sugar left in the molasses by this process than by the ordinary process. In the "Hadi process" there were 37·12% of the total cane sugar left in the molasses after the first boiling and in the ordinary process 34%. The glucose ratio of the molasses from the massecuite prepared by the "Hadi process" was 1 to 1·24, that is for every pound of glucose in the molasses there were 1·24 lbs. sucrose cane sugar present. In the ordinary process the ratio was 1 to 3·55. These figures imply that a very much larger amount of second sugars can be obtained out of the molasses obtained by the ordinary process than that by the "Hadi process." The molasses has not yet been reboiled, but the past experience indicates that if a definite quantity of Hadi process molasses would give 2 lbs. of sugar the same quantity of ordinary molasses would give about 30 lbs. second sugar.

48. *Conclusions.*—On every point on which we have examined the two processes the ordinary process has either been equal to or superior to the "Hadi process," and in most cases decidedly superior. The skimming with the "Hadi process" was on the whole a little easier, but we have been unable to make that a comparative test. All the work was carried out under my direction by Mr. Ramachandra Rao, the Farm Manager. He had no previous experience with either process, and both processes had therefore an equally good chance in his hands. That he did his work well may be judged from the fact that the sample of sugar turned out by the "Hadi process" was as good as that turned out by

Mr. Hadi himself, and that the sugar by the ordinary process was much superior to any which has been boiled here in previous years.

49. The secret of making a light-coloured sugar is very careful skimming and skimming at the right time.

50. *The advantage of the use of bicarbonate of Soda, in the "Hadi process."*—At first sight it may be difficult to understand what possible good there can be in adding a little of a solution of bicarbonate of soda to the acid juice a short time before the latter comes to the boil. It must increase the soluble ash in the massecuite and thus would keep some of the sugar in the molasses which would otherwise crystallise out. The quantity added is too small to appreciably affect the acidity of the juice. It is enough, however, to produce a large number of small bubbles of carbonic acid gas, and some of these get caught in the small particles of "scum" which have already formed but have not yet risen to the surface. Or rather, these bubbles are most easily formed where these solid particles exist. And in rising to the surface they carry the little solid particles with them. The bicarbonate of soda therefore assists in the rapid formation of a good "blanket," as the scum is technically called when it is packed together on the surface of the juice. Possibly the mucilaginous extract from the Bhindi may make this blanket a little tougher than it would otherwise be. But if it does so we have failed to notice that fact.

51. The price realized for the sugar produced this year which was offered for sale was Rs. 2-8-0 per maund of 28 lbs. or only one anna less than refined sugar could be bought for at the same time in the same market. The best quality of jaggory was sold for Rs. 1-8-0 per maund. The juice from which it was made was skimmed to the same extent and in the same way as that from which the ordinary samples of sugar were made.

Plant Food removed by Sugar Cane.

52. In para 50, page 25 of last year's report, octavo form, it was promised that the juice, leaves, top and trash

of sugar cane should be analysed this year to determine the amount of plant food actually removed by sugar cane from the soil. This has been done, and the results are given in Tables No. VIII, No. IX and No. X in the Appendix. The results are calculated on the crop actually grown on the spot where the samples for analyses were taken. That was at the rate of 24·95 tons per acre. From the tables referred to it will be seen that the total amount of plant food removed in the portion of cane above ground (unfortunately the roots could not be analysed this year) is 55½ lbs. of both nitrogen and lime, 68½ lbs. of phosphoric acid and 190 lbs. of potash.

53. These figures therefore show that the sugar cane removed three times as much potash as it did of any of those other constituents of the soil generally supplied to it in fertilizers. The tops and the green leaves together contain more than half of this amount, the green leaves which are usually fed to the bullocks containing most of this.

54. Of the total nitrogen removed fully one-third is in the begasse. But as the begasse decomposes very slowly even if ground up to a fine powder little of this will be available for future crops even if applied to the soil. Undoubtedly it is much more valuable as fuel than as a manure.

55. It may appear strange to some that the dead leaves or trash contained more than one-third of all the lime removed, notwithstanding that they constituted less than 6½% of the total weight of substance removed from the field. The proportion of potash in the dead leaves is not nearly so great, being only a little over 11%. Comparing with this the relative amount of potash and lime in the green leaves we find that they contain for the same amount of lime more than 2½ times the amount of potash. This indicates in conjunction with the figures contained in Table No. VIII that the lime accumulates in the leaves as they are growing and remains there. That on the other hand the potash in the dying leaves is removed and used again in other parts of the

cane. This is quite in conformity with the facts observed elsewhere. But notwithstanding the fact that the potash did not remain to any very large extent in the dead leaves, while the lime did, the cane as a whole contained four times as much potash as lime.

56. These facts certainly indicate that the crop of sugar cane drew heavily on the potash in the soil, and may possibly account why it is found advantageous to give such heavy dressings of oil cake in some places in India if no other fertilizer supplying potash is used. The soil has no doubt a great deal to do with this and probably the variety of cane also. It is possible, however, that where these large applications of oil cake are given sufficient attention is not paid to the potash or phosphoric acid requirements of the cane. Should this be the case it may perhaps be possible to reduce the cost of manures for sugar cane very materially without reducing the returns. I need not say that manurial experiments with cane will be begun as soon as possible and that the testing of this point will form the basis of these experiments.

57. *Tables.*—In the appendix are given a number of tables which practically speak for themselves. Table No. 1 contains the weights of sugar cane, tops, begasse and jaggory or massecuite, actually obtained from the plots. The composition of the juice and jaggory are also given. A small portion of the cane from each plot which was not milled with the bulk of the cane is not included in these figures. Table No. II gives the total yields each plot would probably have given if this cane used in other ways had also been milled at the regular harvest time. For this calculation it is taken for granted that the cane used for these other purposes had the same composition as that which is given in Table No. I. Table No. III gives the loss of cane sugar due to inversion while boiling down the juice for all the samples of juice limed to neutrality. Table No. V gives the decomposition of sucrose into glucose during the latter part of the season when the glucose content of the juice was re-

latively higher than in the early part of the season. It has been noticed before that juice which contains a lot of glucose to begin with frequently loses more sugar by inversion during boiling than juice which has little glucose, notwithstanding that both are limed in the same way. Table No. IV shows the results obtained when boiling sugar by the "Hadi system," and Table No. V gives the results obtained when boiling sugar from similar juice in the ordinary way. Table No. VI groups together all the samples of juice milled during the same week of the harvest season, giving the composition of the juice and the date on which it was milled. And Table No. VII gives the results of the analyses of the juice from two of the varieties of cane grown on the Farm when cut at different periods. Six average canes were selected from time to time from each plot. These were cut and the juice analysed to find out when the cane was ripe and how long it would remain at this its best stage.

PADDY.

58. In Table No. 1, page 6 of last year's report, are given the yields of grain obtained from the wet area in the first two crops of paddy. It was intended to plant this year the same variety of paddy as that used in 1906. But the Farm Manager had not sown enough seed in the nursery to plant the entire area in the usual way. To save time a "sixty days" paddy which had been imported the previous year from Madras was used instead. This grew fairly well until after it had shot into ears, though not as vigorously as the "Chintamani Sannabhatta" had done the previous year.

59. When the harvest time approached it was found that practically none of the ear heads had filled. A little later fresh shoots were sent up, and in the hope that these might possibly produce grains the experiment was tried of letting the paddy remain on the field until these new shoots were mature. But this experiment was a failure as no grain formed in the second crop of ear heads.

60. The transplanting of the paddy from the nursery to the experimental plots began on October 8th, and was finished on the 15th of October. The paddy was cut on the 7th and 8th of February. No manure was used for this crop and none had been used for the two previous crop of paddy.

61. Before it was found out that the paddy on the Farm had formed no grain, several samples of paddy which had not formed grain were sent by raiyats from various localities in the State with the request to identify the disease and give a remedy for the same. But Dr. Butler, the Imperial Mycologist, was unable to find any trace of disease on the samples sent him. These included a sample from the Experimental Farm.

62. Before sending these samples to Dr. Butler I examined them as carefully as I could. But the only abnormal thing I could find was that the cells of the straw were full of starch. Apparently the starch which is usually stored in the grain had been formed, but there being no grain in which it could be deposited it remained in the straw. This was therefore of a higher feeding value than it would otherwise have been. That is, however, a poor compensation for the loss of grain.

63. Several suggestions have been made as to the possible causes for the non-formation of the grain. One of these was that the variety had been newly imported. But as the seed from which this crop had been produced had grown on another part of the same farm the previous year, and the crop of which this seed formed a part had been a good one, this could hardly be the cause. Another suggestion was that the climatic conditions at the time when the paddy was flowering were possibly very abnormal. Nothing very abnormal was noted about the season, and the fact that the second crop of ear heads (which flowered several weeks after the first crop had flowered) also failed to produce grain, speaks against this theory. A third suggestion was that the land might have been in bad manurial condition, having had no manure for at least three successive seasons. Some of the land was no

doubt very poor. But the best plots had produced more than at the rate of 1½ tons of grain to the acre per season for the two previous seasons, and the area as a whole had shown no deterioration in its crop return the previous season. Besides, if the failure to form grain had been due to this cause the best plots would undoubtedly have produced whatever little grain was produced. But in both ranges the best plots gave absolutely no grain, while in range B the poorest plot gave the most grain—2 lbs. 9 oz.—and in range C an average plot gave the most grain, 5 lbs. 5 oz. To none of these reasons in themselves can, I think, be assigned the failure to produce grain. If any of them have any bearing on the subject at all they can only have formed one of several causes which may have worked together to produce this very undesirable result.

64. The next crop of paddy was still growing on the experimental plots when the official year closed. It was nearing maturity and the grains had formed well.

DRY AREA.

65. *Ragi.*—All the plots which may possibly be used for experimental purposes in the dry area were uniformly treated and sown with ragi without using manure or growing any leguminous crops between the rows. The crop was cut on November 15th and 16th. But owing to the large amount of work connected with the sugar cane harvest this year the thrashing of the ragi was not finished at the close of the official year.

66. During the time the ragi was growing there was a considerable amount of rain, and the subsoil water came to within 18 inches of the surface at a spot 4 feet, 7 inches above the high water level of the tank. There was also a considerable wash of surface soil shortly after sowing before the ragi could protect the soil. These are some of the factors which have contributed to considerably reduce this year's crop. As in the previous year, there is a considerable difference in the crop produced by the various plots. But all this will have to be reported on next year.

GARDEN CROPS.

67. Nearly all the garden crops did very poorly this year. The heavy rains were largely to blame for this. Ground nuts and brinjals suffered badly from disease. Turmeric and ginger did fairly well. Sweet potatoes gave decidedly below an average crop. Below are given the five crops of sweet potatoes harvested since the experiment began:—

Year	New Jersey	Nansemond	Virginia
	lbs. per acre	lbs. per acre	lbs. per acre
1903 ...	14,170	14,870	13,050
1904 ...	14,170	8,760	8,600
1905 ...	22,100	20,880	21,050
1906 ...	7,370	12,000	5,480
1906 ...	11,400	9,300	10,200
Average ...	13,840	13,160	11,670

68. As will be noticed, the New Jersey gave the highest average yield.

69. Onions (fadgiri) did very well; one plot yielding at the rate of 25,000 lbs. per acre and another plot at the rate of 19,000 lbs. per acre. Some of the largest onions weighed 1 lb. each.

COTTON.

70. *Carovonica cotton.*—Both the No. 1 and No. 2 varieties continued to grow, though not as well as last year. Those planted in October 1905 gave on an average of a little over 1½ oz. clean cotton per tree during the year. Those planted in April 1906 gave a little under 1½ oz.

71. A Bolivian cotton planted 5 years ago produced a little over 2 oz. per tree, but was badly attacked by scale insects.

SOIL MOISTURE.

72. *Capillarity.*—With a view of determining the depth at which the subsoil water was from the surface of the soil at various points on the farm, some of the old wells on the dry area of the farm were retained and some new ones were dug. One of these new ones was about 450 feet from the edge of the tank where the surface of the soil was 4 feet 7 inches higher than the high water level of the tank and a little over 13 feet above the bottom of the tank. This well was surrounded by a little bund to prevent the surface water running into it. Throughout the season the water in it never dropped below 6 feet 6 inches from the surface even when the tank was dry and as a rule was within 3 feet of the surface. Notwithstanding this the surface soil around the well never appeared to be excessively wet at any time. And in the beginning of the dry season the surface soil of the area around this well in which the water stood at 1 foot 7 inches from the surface at that time did not appear to have more moisture than that of other parts of the field where the surface of the subsoil water was 5 feet or 10 feet or even 25 feet below the surface of the soil. If, as it appeared to be, the soil at the surface was really as dry near this spot where the subsoil water was so near the surface, it would of course indicate that the capillarity of this soil is not nearly as great as the capillarity of soils in general is supposed to be.

73. On November 26th, a boring was made close to this well and the moisture determined in every successive 3 inches of soil. Beginning with the sample extending from the surface to 3 inches below it, the following figures give the percentage of water found in the successive layers of soil:—3·62, 6·31, 10·64, 13·65, 14·33, 14·85. The last of these samples just touched the subsoil water.

74. The soil is a laterite loam. No physical analysis was made of these particular samples, but in appearance they closely resemble a soil from the neighbourhood having the following composition:—

Approximate size of particles	Equivalent to remaining on top of a sieve having about the following No. of meshes to the linear inch	Per cent
Larger than 4 mm. in diameter ...	5	0·00
Between 2 mm. and 4 mm $\frac{1}{8}$ ...	10	1·34
,, 1 ,, ,, 2 mm. $\frac{1}{16}$ ...	20	8·13
,, $\frac{1}{2}$,, ,, 1 mm. $\frac{1}{32}$ ...	40	6·54
,, $\frac{1}{4}$,, ,, $\frac{1}{2}$ mm. $\frac{1}{64}$ ...	60	10·34
,, $\frac{1}{8}$,, and $\frac{1}{4}$mm. $\frac{1}{128}$ ...	90	18·90
Particles settled to the bottom of a bottle containing 8 inches of water in the following periods of time—		
$\frac{1}{4}$ minute on an average about $\frac{1}{250}$ inch in dia.		10·11
1 do do $\frac{1}{500}$ do		5·39
10 do do $\frac{1}{5000}$ do		9·30
After 10 minutes do $\frac{1}{50000}$ do		29·83

75. On December 5th, samples of soil were again taken for moisture determinations. This time a separate sample was taken every $1\frac{1}{2}$ inches in three different places on the field. Series 1 was taken within 4 feet of the shallow well in which the water stood on that date 1 feet 7 inches below the surface of the soil. Series No. 3 was taken 230 feet further away from the tank, near another well in which the water stood 5 feet 6 inches from the surface of the soil, and Series No. 2 was taken at a point midway between these two:—

Depth at which the sample was taken	Per cent of water		
	Series 1	Series 2	Series 3
Surface to 1½ inches deep	1·94	1·87	1·90
From 1½ inches deep to 3 inches deep ...	2·07	2·84	3·77
Do 3 do to 4½ do ...	3·63	3·59	2·91
Do 4½ do to 6 do ...	4·47	3·49	4·50
Do 6 do to 7½ do ...	7·57	4·34	5·83
Do 7½ do to 9 do ...	9·42	4·81	6·59
Do 9 do to 10½ do ...	10·95	5·53	9·41
Do 10½ do to 1 foot deep ...	11·77	5·35	10·11
Do 1 foot deep to 1 foot and 1½ inches deep	12·55	5·67	11·35
Do 1 foot 1½ inches deep to 1 foot 3 inches deep	13·26	5·69	11·81
Do 1 do 3 do to 1 do 4½ do	13·80	6·59	12·27
Do 1 do 4½ do to 1 do 6 do	14·10	7·41	12·64
Do 1 do 6 do to 1 do 7½ do	14·99	9·27	12·38
Do 1 do 7½ do to 1 do 9 do	15·05	10·18	12·93
Do 1 do 9 do to 1 do 10½ do	...	10·72	13·14
Do 1 do 10½ do to 2 do deep	...	10·99	13·73

76. As far as these figures go there is nothing to indicate that the top 5 or 6 inches of soil at the place where the surface of the subsoil water was only one foot and seven inches from the surface contained more water than those in places where the subsoil water was much lower. There appears, however, to be something abnormal about Series No. 3. For, although these samples were taken within a few feet of a well in which the water stood at 5′ 6″ from the surface, the water content of the samples below 2′ rapidly rose until it reached 15·37 % of water at a depth of 3′ 3″. Then it remained almost constant till the level of the water in the well was reached and no further samples were taken. In Series No. 2 water was reached as four feet and, as in Series No. 1, the samples contained 12 % or a little less water to within about 6″ of the subsoil water level. Lack of time and appliances unfortunately prevented a more detailed study of this important problem on soils *in situ*.

77. Similar soils were filled into glass tubes. The lower end of these glass tubes when in a vertical position were immersed into water with the object of seeing how quickly and how far the water would rise in the soil contained in these tubes. In 24 hours it rose to 14 inches and in one case to 18 inches above the surface of the water into which these tubes were dipped. After that it rose very slowly, reaching in three weeks from 22 inches to 24 inches in height. These results confirm those obtained on soils *in situ*. Both appear to indicate that on soils like those experimented with the subsoil water has practically no effect in supplying water to the plant unless it is within two feet of the point to which roots descend.

78. *Drying out of soils.*—In order to make a preliminary study of this subject, 24 borings were made to a depth of 6 feet at various times on plots in the Laboratory compound. These plots were uniformly treated up to November 1st, 1906. The surface soil had been kept loose to a depth of about 4″ for about two months. On October 14th, the first boring was made and the moisture determined in every 6″ of soil. On November 1st, one plot was rolled heavily so as to represent uncultivated soil. Another plot was kept stirred on the surface to a depth of about $1\frac{1}{2}$ inches. A third plot was dug to a depth of about $1\frac{1}{2}$ feet and on a fourth plot Bengal gram was sown.

79. Borings were made on these plots from time to time up to February 6th, 1907. The percentage of water found at various depths is given in Table No. XI in the Appendix. Nearly 400 samples of soil were taken and their water content ascertained. During the time that this work was being carried out a number of small showers of rain fell. Table No. XII, kindly sent by the Director of the Meteorological Department, gives the rainfall during this time. The rain gauge is within 300 feet of these plots.

80. The average depths to which the effect due to the evaporation of water from the surface of the soil could be distinctly noticed was as follows:—

Uncultivated plot	Cultivated 1½ inch deep	Cultivated 1½ feet deep
1 foot 9 inches	1 foot 6 inches	1 foot 6 inches

The last borings were taken nearly 1 month after the last shower of rain fell. In these the effect due to the loss of water by evaporation did not extend to more than 1′ 6″ in either of the cultivated plots. But in the uncultivated plot it probably extended to about 2′ 6″ depth, and possibly further than that.

81. The Bengal gram was only a light crop. The soil in the laboratory compound is very poor and no manures were used. Notwithstanding this the loss of moisture from the plot on which this crop grew was very much greater than from any of the other plots. Only one boring was taken on that plot and it is therefore not safe to draw deductions from it until confirmed. It appears to indicate, however, that even this light crop of Bengal gram drew on the water-supply of the soil to a depth of more than 6 feet. The difference in moisture between the gram plot to a depth of 6 feet and the uncultivated plot would have been compensated for by an application of 3 inches of water over the entire plot and between it and the plot cultivated 1½ inches deep by an application of about 5½ inches of water. The total loss of water by evaporation percolation, etc., during the period from October 14th to February 6th, amounted, when considering only the two feet of soil nearest the surface on the uncultivated plot, to about two inches in excess of the rainfall, to about 1·6 inches on the plot dug 1½ feet deep and about 1·5 inches on the plot cultivated 1½ inches deep. Keeping the surface soil loose for 1½ inches acted, therefore, in this instance as well in preserving soil moisture as keeping it stirred 1½ feet deep. The extra loss of water from the upper two feet of the uncultivated soil in this experiment amounted only

to the equivalent of about half an inch of rainfall during the time required for the experiment. The saving of such a small amount of moisture can, I think, hardly account fully for the great advantage constant cultivation is known to have upon the growth of crops, unless the moisture content causing the most vigorous growth in this particular soil lies much below 12%, and comparatively slight differences in the water content of the soil have a very marked influence on the growth of plants. The fact that in the pot culture experiments a mulch produced a beneficial result on the crop (*vide* para 91, page 18 of this report), notwithstanding that the water content of the soil was practically constant, also appears to indicate that keeping the surface of the soil loose has other beneficial effects than that of preserving moisture in the soil. It is, therefore, a subject requiring further investigation.

82. A glance at Table No. 11 will show that the water content of these soils does not increase uniformly with their depth. The variations are probably due to the mechanical condition of the soil not being uniform. It will also be noticed that the soil has a tendency to retain about 12% of water up to within 2 feet of the surface.

83. The work will be continued next year.

POT-CULTURES.

84. As mentioned in para 51, page 25 of last year's report, experiments with bone meal were begun in the pot-culture house with a view of determining if possible the factors which contribute to make bone meal a comparatively readily available phosphatic fertilizer. The fact that bone decomposed very readily on one estate on which it had been applied on the surface of the soil on top of a layer of leaves, while on another estate, on which it had been buried in pits, it had not completely decomposed in 29 years, led me to the idea that either the carbonic acid of the decomposing leaves or the micro-organisms which develop in the decomposing leaves had

something to do with the decomposition of the bone meal on the one estate referred to. On that estate there is a, more or less, continuous leaf fall from the coffee and the shade trees growing on it, so that the bones were soon covered by a layer of leaves which kept them moist and retained the carbonic acid generated by the decomposing leaves below.

85. To imitate this condition leaf mould, as generally used by the gardeners, was used on some of the pots and ground sugar cane refuse (begasse) on others. As the soil used for these experiments had not been tested in regard to its manurial requirements and there was no certainty that phosphatic fertilizers were required by the soil, the bone meal used for these experiments was coarse enough to permit all which had not been decomposed to be sifted out of the soil again after the experiment was over. The difference between the weight applied and the amount sifted out again would, it was supposed, indicate fairly accurately the amount decomposed. By this means it was hoped to be able to determine the rate of decomposition of the bone meal in the various pots, even if the soil did not respond to phosphatic fertilizers. For the sake of comparison some fine bone meal was also used.

86. All the usual precautions, necessary to obtain reliable results with pot-cultures, were taken. But unfortunately neither the vegetable mould, which by the way contained 75 % of sand, nor the begasse decomposed to any appreciable extent. The results do not, therefore, give the information desired, and a new set of experiments has been started on a larger scale. The experiments which have been made are, however, of value on account of other information which can be gathered from them.

87. For all the experiments made during the year 16·6 grams of bone meal were used in each pot. The coarse bone meal varied from 2 mm. to 5 mm. in diameter and the fine bone meal had all passed through a sieve having 40 meshes to the linear inch. In some experi-

ments the bone meal was mixed with the top two inches of soil. In others it was applied on the surface of the soil. In the latter experiments the bone meal was covered with either 8 ounces of leaf mould or 3 ounces of ground begasse. Some of the pots in which the bone meal was mixed with the soil were also covered with begasse.

88. The following is the average weight of the bone meal sifted out of the soil from these pots after the experiment was concluded :—

How the bone meal was applied	Bone meal sifted out by using 1 mm. sieve	Bone meal which passed through 2 mm. sieve
	gr.	gr.
Mixed with top 2 inches of soil uncovered ...	14·6	0·37
,, ,, covered with begasse ...	14·2	0·98
Bone applied on top covered with begasse ...	15·2	0·24
Bone applied on top covered with leaf mould	14·3	0·67

89. As might have been expected under the circumstances, none of these figures show any rapid decomposition of the coarse bone meal. In these experiments the bone meal mixed with the soil had decomposed a little more than that applied to the surface ; and a covering of leaf mould had a slightly better effect than that of begasse. Probably the former decomposed a little more than the latter. It was of course impossible to remove either mulch from the surface of the soil without removing a little of the soil as well. And the results of the experiments did not justify the analysis of either the leaf mould or begasse after the experiment was concluded.

90. The crop returns were as follows :—

Manures applied to pots	Dry matter	
	In straw gr.	In grain gr.
1. No manure	5·7	281
2. No manure covered with 3 oz. begasse ...	9·4	5·63
3. No manure covered with 8 oz. leaf mould ...	10·5	7·45
4. Dried blood and sulphate of potash ...	132·2	43·70
5. Dried blood and sulphate of potash covered with begasse	134·0	48·99
6. Fine bone meal, dried blood and sulphate of potash all mixed with soil (uncovered)	137·8	56·26
7. Coarse bone meal, dried blood and sulphate of potash all mixed with soil (uncovered) ...	125·5	49·22
8. Coarse bone meal, dried blood and sulphate of potash, bone meal on top of soil, covered with begasse	131·5	50·39
9. Coarse bone meal, dried blood and sulphate of potash, all mixed with soil, covered with begasse ...	139·5	52·8
10. Fine bone meal, dried blood and sulphate of potash, all mixed with soil and covered with begasse	136·0	57·5

91. These results indicate that a mulch of begasse has a slight beneficial result on the growth of ragi (the crop used for these experiments), and that a mulch of leaf mould has a somewhat greater beneficial effect than the begasse. This is the case, notwithstanding that none of the plants suffered for want of water, for the pots were watered every day and all the water lost by evaporation during the day was replaced in the evenings. This beneficial result is seen throughout the series and may be noticed by comparing the returns for the unmanured pots, No. 1, 2 and 3; the pots manured only with sulphate of potash and dried blood No. 4 and 5; those in which fine bone meal was also used, 6 and 10; and those in which coarse bone meal was used instead, *viz.*, No. 7 and 9. Experiments Nos. 4 and 7 and Nos. 5 and 9 show that the coarse bone meal has had some effect on the crop, though a comparatively small one. And Nos. 6 and 7 and Nos. 9 and 10 show that the fine bone meal was more effective than the coarse bone meal used. These

results are particularly interesting on account of the complete harmony which exists between them. There is not a contradictory result among them. And as this is the first series of pot-culture experiments conducted here, this is particularly encouraging, notwithstanding that it has given very little information on the principal point for which these experiments were started.

92. *Preparation of soil for pot-culture work.*—In order to conduct pot-culture experiments with manures such as attempted this year it is necessary to have a soil in which the particular manures selected for experiment act to advantage. In other words the soil must be deficient in that particular ingredient of plant food with which experiments are to be carried out. Of course such soils exist naturally, but to find them sometimes necessitates a large number of analyses and a considerable number of preliminary experiments. Besides, it generally implies shipping them some distance, and sometimes shipping them from a place very far away. To overcome these difficulties, as far as possible, it is generally advisable to prepare soils artificially for these experiments. This is done by manuring as poor a soil as can be conveniently secured in a one-sided way and cropping it for successive years as much as possible. This will gradually remove the available plant food in the direction desired. If, for example, a soil already relatively poor in phosphoric acid is heavily manured with all the other constituents of plant food and continuously cropped (if possible with a plant making heavy demands on the phosphoric acid content of the soil) the available phosphoric acid will gradually be reduced to a point where the plant will not be able to get a sufficient supply of phosphoric acid for its normal growth. When that point is reached the soil can be used to advantage for such experiments as testing the relative availability of bone meal, superphosphates, basic slag and other phosphatic fertilizers; or for conducting such experiments as the availability of bone meal under different conditions as was attempted during the year which has just closed.

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93. For the purpose of exhausting soils in any desired direction six pits 8′ × 10′ were built of stone. These were refilled to within 1′ 9″ from the top and on top of this strips of Cuddappah slabs 1½″ thick and 9″ wide were set on their edge 9″ apart. The refilling was then continued to the upper edge of these strips. The remaining foot was filled in with the soil selected for the one-sided exhaustion to fit it for a particular line of pot-culture experiments. The strips of the Cuddappah slab form, in a way, a perforated bottom to the pits in question, and indicate the depth to which the soil may be removed when dug out for use in the pot-culture house.

94. On these "preparation beds," as the above plots are called, the first crop is now growing.

"FAMINE FOODS."

95. In response to a Government Order, "famine foods" were collected by the Revenue and Forest Departments and sent to this laboratory for analyses.

96. A reference to this work was made in para 52, page 26 of the Fifth Annual Report.

97. Since then a large number of samples of so-called "famine foods" have been received. Sometimes these samples arrived in very bad condition so that it was necessary to ask the senders to supply other samples. All of these samples have not yet been received, and some samples are likely to come in even now. The samples are therefore not yet complete; among other things the fruit of the prickly-pear, which is said to have been successfully used as a "famine food" has not yet been sent. Moreover, there has been so much work which had to be attended to at once that many of the samples already received have not yet been analysed. However, a sufficient amount of work has been done to justify the results obtained thus far being given in this report.

98. All samples received were sent to Mr. Cameron, Superintendent of Government Gardens, for identification, and all the botanical names are given on his authority.

99. From the list of samples sent in, as given in the appendix, it is evident that the term "famine food" conveys a different meaning to different people, for among the samples received was the ordinary paddy, which few would be prepared to classify under the head of "famine foods." But, as in the absence of a precise definition of the term, it is impossible to draw a sharp line of division between ordinary foods and famine foods, I have included everything sent in as a "famine food" in the tables given in the appendix.

100. Besides their food value, it would be desirable, as pointed out in the Fifth Annual Report, to determine if any of them had an injurious effect on the system if eaten for some time. But if it is remembered that this entails a long series of feeding experiment under close medical supervision, it will be apparent that this is impossible at present.

101. One of the chief points to be considered about "famine foods" is, no doubt, whether they can be got in large quantities during a famine time.

102. Of the "foods" given in Table No. XIII young bamboo shoots are the most nutricious. The air-dried sample appears to be nearly as valuable as gram or dhal, and decidedly more valuable than either rice or ragi. But unfortunately the young shoots contain only a little over $7\frac{1}{2}$ per cent dry matter. This implies that more than 10 lbs. of green shoots will have to be eaten to supply as much nourishment as is contained in one pound of gram or dhal.

103. The shoots analysed were those of the young bamboos when just above ground. The outer covering was removed and the succulent tender part inside was analysed. The weight of these varies, of course, considerably, but none of them are very large. An average shoot removed from a clump of small bamboos growing to a height of about 10 feet weighed, when prepared, a little over half an ounce.

104. Babul seeds have the highest nitrogen content of all those "famine foods" sent us in which that consti-

tuent has been determined. And this notwithstanding that more than half their weight consists of a very hard covering nearly $\frac{1}{32}$ of an inch thick. They contained over 6 per cent nitrogen. When boiling the seeds for three-quarters of an hour or more they rise to the surface of the water and the skin can then be easily cut with a knife, but it is doubtful if even then the skins are digestible. The inside of the seed has a pleasant dhal-like taste, and if any means can be devised for getting this out of its thick hard covering it will probably rise to the rank of an ordinary food, if sufficient quantities of it can be obtained and it has no injurious effect on the system. When boiled for one hour or more the skins are soft enough to be easily eaten.

105. Table No. XIII in the appendix gives the composition of 21 of the so-called "famine foods." The albumenoids have been calculated from the total nitrogen. The non-albumenoid nitrogen has not been determined. The total nitrogen of 44 other "famine foods" has been given in Table No. XIV, and Table No. XV gives such general information about the "famine foods" received up to date as is available at present.

A. LEHMANN,
Agricultural Chemist.

TABLE No. I.

Weight and composition of juice and jaggory (or massecuite) obtained from sugarcane plots. Plot I.

Rows	Pan	Juice					Jaggory or Massecuite				
		Weight	Sucrose		Glucose		Weight	Sucrose		Glucose	
		lbs	%	Total weight lbs	%	Total weight lbs	lbs	%	Total weight lbs	%	Total weight lbs
1 & ½ of 2 ...	...	249	19·85	49·43	·30	0·747	49	85·20	41·75	3·80	1·86
4,3 & ½ of 2 ...	...	367	20·75	76·20	·28	1·028	74¾	82·40	61·59	6·41	4·79
5,6 & ½ of 7 ...	...	438¾	21·15	92·35	·46	2·108	102¼	68·70	70·24	13·70	14·00
½ of 7 & ½ of 8....		Cut for seed and other purposes.									
9 & ½ of 8 ...	...	227¼	20·20	45·90	·48	1·091	49½	77·40	38·31	8·20	1·06
10,11 & ½ of 12	1	281½	20·50	57·71	·29	0·816	56¼	88·50	49·78	1·85	1·04
	2	262	20·50	53·71	·26	0·681	53	88·40	46·85	2·16	1·14
13 & ½ of 12 ...	...	318¾	20·40	65·03	·31	0·988	7⅛3	87·00	58·72	1·88	1·27
Total ...	..	2144¼	...	440·33	...	7·459	452¼	...	367·24	...	28·16
Average ...	...	...	20·54	...	0·35	...	...	81·20	...	6·23	...

Weight and composition of juice and jaggory (or massecuite) obtained from sugarcane plots. Plot II.

1 & ½ of 2 ...	...	256	20·55	52·62	·18	·460	49	85·50	41·89	4·62	2·26
3,4 & ½ of 2...	1	248¼	20·45	50·77	·34	·844	50	83·10	41·55	5·81	2·90
	2	196½	20·25	39·79	·41	·805	35¾	85·45	33·11	5·95	2·30
5,6 & ½ of 7*...	1	343	21·25	72·89	·31	1·063	81¼	71·80	58·34	7·24	5·88
	2	272	21·15	57·53	·29	·789	60⅛	73·40	44·41	8·77	5·31
½ of 7 & ½ of 8...		Used for seed and other purposes.									
9 & ½ of 8 ...	...	272	19·75	53·72	·32	·870	49	80·50	39·45	9·43	4·62
10,11 & ½ of 12	1	296¼	20·80	61·62	.24	·711	62	86·50	53·63	3·08	1·91
	2	206¼	20·85	43·00	·24	·495	38½	86·80	33·42	5·26	2·03
13 & ½ of 12 ...	...	414	19·95	82·59	·29	1·200	77	85·10	65·53	3·18	2·45
Total ...	...	2504¼	...	514·53	. .	7·237	506	...	411·33	...	29·66
Average ...	...	...	20·55	...	·29	...	...	81·29	...	5·86	...

* 11 lbs. of juice used for other experiments.

TABLE No. I—*contd.*

Weight and composition of juice and jaggory (or massecuite) obtained from sugarcane plots. Plot III.

Rows	Pan	Juice					Jaggory or massecuite				
		Weight	Sucrose		Glucose		Weight	Sucrose		Glucose	
		lbs	%	Total weight lbs	%	Total weight lbs	lbs	%	Total weight lbs	%	Total weight lbs
1 & ½ of 2 ...	...	305¼	20·15	61·50	·18	0·549	63⅜	83·20	53·04	4·90	3·12
3, 4 & ½ of 2...	1	242⅜	20·45	49·59	·37	0·897	46¼	83·00	38·39	7·57	3·50
	2	244¼	20·50	50·07	·28	0·684	49⅜	83·00	41·29	6·58	3·27
5, 6 & ½ of 7...	1	436	20·85	90·91	·40	1·744	05	67·85	71·24	12·50	13·12
	2	295¼	20·75	61·26	·57	1·478	168⅜	75·10	51·63	6·94	4·77
½ of 7 & ½ of 8...	...	Used for seed and other purposes.									
9 & ½ of 8 ...	...	401	19·70	79·00	·77	3·088	82½	75·50	62·29	9·26	7·64
10, 11 & ½ of 12	1	290⅜	20·15	58·53	·33	0·958	61¼	86·10	52·74	3·24	1·98
	2	320¾	20·10	64·47	·41	1·315	66⅜	86·00	57·40	3·16	2·11
	3	385⅜	20·35	78·50	·32	1·234	81⅜	85·50	69·90	4·00	3·27
13 & ½ of 12	1	236	20·05	47·32	·32	0·755	47	87·40	41·08	3·84	1·80
	2	217⅜	19·75	43·00	·37	0·806	35¾	87·10	31·14	3·37	1·20
Total ...	...	3375	...	684·15	...	13·508	708½	...	570·14	...	45·78
Average ...	...	...	20·27	...	0·40	...	...	80·47	...	6·46	...

Weight and composition of juice and jaggory (or massecuite) obtained from sugarcane plots. Plot. IV.

1 & ¼ of 2 ...	...	389	20·35	79·16	·22	0·856	81½	82·60	67·23	3·40	2·77
3, 4 & ½ of 2...	1	448	20·80	93·14	·35	1·568	88	80·20	70·58	9·10	8·01
	2	238	20·50	48·79	·43	1·023	43½	80·10	34·84	5·20	2·26
5, 6 & ¼ of 7...	1	365¼	21·10	77·07	·47	1·716	82	76·30	62·57	8·33	6·83
	2	351	20·85	73·18	·53	1·860	81¾	75·20	61·48	9·09	7·43
½ of 7 & ½ of 8...	...	Used for seed and other purposes.									
9 & ½ of 8 ...	...	395¼	19·55	77·27	·65	2·569	88⅜	62·65	55·60	18·70	16·60
10, 11 & ½ of 12	1	403¼	20·65	83·27	·34	1·371	84½	84·70	71·57	5·26	4·44
	2	408	20·05	81·80	·36	1·468	85⅜	85·90	73·66	4·38	3·76
13 & ½ of 12...	1	263¼	20·25	53·31	·36	0·947	52⅜	85·20	44·94	5·20	2·74
	2	258	20·45	52·76	·32	0·826	55½	85·10	47·23	4·09	2·27
Total ...	...	3519	...	719·75	...	14·204	744	...	589·70	...	57·11
Average ...	...	...	20·45	...	0·42	...	...	79·26	...	7·68	...

TABLE No. I—*contd.*

Weight and composition of juice and jaggory (or massecuite) obtained from sugarcane plots. Plot V.

Rows	Pan	Juice					Jaggory or massecuite				
		Weight	Sucrose		Glucose		Weight	Sucrose		Glucose	
		lbs	%	Total weight lbs	%	Total weight lbs	lbs	%	Total weight lbs	%	Total weight lbs
1 and ½ of 2 ...	...	253	20·10	50·85	·23	0·581	53½	85·80	45·90	4·71	2·52
3, 4 and ½ of 2	1	275¾	20·95	57·77	·23	0·634	53½	83·70	44·78	6·17	3·30
	2	204	20·75	42·33	·29	0·592	37¾	86·60	32·69	4·54	1·71
5, 6 and ½ of 7	1	378¾	20·35	77·08	·50	1·894	76	79·20	60·19	8·77	6·66
	2	281½	20·60	57·99	·58	1·633	58¼	84·20	49·05	5·61	3·27
½ of 7 and ½ of 8	Used for seed and other purposes.										
9 and ½ of 8 ...	...	369	19·95	73·62	1·22	4·502	78	74·00	57·72	12·60	9·83
10, 11 & ½ of 12	1	388½	20·75	80·61	·47	1·826	79¾	85·70	68·35	4·38	3·49
	2	354	20·85	71·72	·39	1·341	75	85·50	64·12	3·90	2·93
13 and ½ of 12...	...	463½	20·15	93·40	·30	1·390	95	81·10	77·04	5·81	5·52
Total ...	...	2,968	...	605·37	...	14·393	606¾	...	499·84	...	39·23
Average ...	...	...	20·40	...	0·48	...	...	82·38	...	6·47	...

Weight and composition of juice and jaggory (or massecuite) obtained from sugarcane plots. Plot VI.

1 and ½ of 2 ...	...	344½	20·30	69·93	·24	0·827	70¼	86·40	60·91	3·30	2·33
3, 4 and ½ of 2	1	289¾	20·50	59·40	·32	0·927	60¼	83·50	50·31	5·88	3·54
	2	333¾	20·50	68·42	·33	1·101	68	83·90	57·05	5·88	4·00
5, 6 and ½ of 7	1	370½	21·00	77·80	·31	1·149	73½	84·00	61·74	5·50	4·04
	2	247½	20·75	51·36	·46	1·138	46½	84·30	39·20	6·09	2·83
½ of 7 and ½ of 8	Used for seed and other purposes.										
9 and ½ of 8 ...	...	382¾	19·70	75·40	·85	3·253	83	60·00	49·80	23·81	19·76
10, 11 & ½ of 12	1	409	20·40	83·44	·36	1·472	83½	85·70	71·56	5·00	4·17
	2	326½	20·25	66·12	·36	1·175	69	84·70	58·44	5·26	3·63
13 and ½ of 12...	...	391¾	19.35	75·80	·51	1·998	80	87·10	69·68	4·95	39·6
Total ...	...	3,096	..	627·67	...	13·040	634¼	...	518·69	...	48·26
Average ...	...	...	20·27	...	0·42	...	...	81·78	...	7·61	...

TABLE No. I.—*contd.*

Weight and composition of juice and jaggory (or massecuite) obtained from sugarcane plots. Plot VII.

Rows	Pan	Juice					Jaggory or massecuite				
		Weight	Sucrose		Glucose		Weight	Sucrose		Glucose	
		lbs.	%	Total weight lbs.	%	Total weight lbs.	lbs.	%	Total weight lbs.	%	Total weight lbs.
1 & ½ of 2 ...	1	282½	19·85	56·08	·58	1·638	55¼	84·95	46·93	3.50	1·93
	2	199½	20·25	40·40	·63	1·257	38½	84·60	32·57	4·27	1·64
3, 4 & ½ of 2..	1	296¼	20·55	60·88	·64	1·896	61¼	85·80	52·55	4·90	3·00
	2	294¾	20·55	60·57	·71	2·093	63½	83·50	53·02	7·04	4·47
5, 6 & ½ of 7 * ...		414¾	20·50	85·02	·84	3·484	87¾	80·20	70·38	8·93	7·75
9 & ½ of 8 * ...		215¾	19·75	42·61	1·35	2·913	47½	72·65	34·51	11·90	5.65
5 to 9 † ...		264¼	16·10	42·58	2·16	5·713	41	72·70	29·81	13·50	5·54
10, 11 & ½ of 12	1	400	21·00	84·00	·64	2·560	89	83·40	74·23	7·24	4·44
	2	285¾	20·95	59·86	·65	1·857	63¼	85·10	53·83	5·74	3·63
1 & ½ of 12 ...	1	255¾	19·25	49·23	·57	1·458	44¾	85·70	38·35	4·34	1·94
	2	259	19·85	51·41	·54	1·399	50½	86·75	43·81	3·70	1·87
½ of 7 & ½ of 8...		Used for seed and other purposes.									
Total ..	...	3,168¾	...	6,32·64	...	26·268	642¾	...	529·99	...	41·86
Average ...	...	...	19·97	...	0·83	...	...	82·52	...	6·52	...

* Except 28ft. which lodged. † last 28 ft. lodged.

Weight and composition of juice and jaggory (or massecuite) obtained from sugarcane plots. Plot. VIII.

1 & ½ of 2 ...	1	254½	19·50	49·63	·49	1·25	51½	85·50	44·03	4·55	2·34
	2	233	19·90	46·37	·46	1·07	44	86·40	38·02	4·23	1·86
3, 4 & ½ of 2...	1	298¼	20·55	61·29	·44	1·31	63¾	85·20	54·31	4·46	2·84
	2	319¾	20·95	66·97	·49	1·57	68¾	85·70	58·92	4·34	2·98
5, 6 & ½ of 7...	1	371¼	20·50	76·09	·67	2·49	80	76·60	61·28	10·80	8·64
	2	272¼	20·60	56·08	·70	1·91	60½	77·30	46·77	11·90	7·20
½ of 7 & ½ of 8..		Used for seed and other purposes.									
9 & ½ of 8 ...		352¾	20·10	70·90	·80	2·82	80	61·90	49·52	18·87	15·096
10, 11 & ½ of 12	1	373¾	20·65	77·18	·45	1·68	79	81·25	64·19	7·57	5·98
	2	372¾	20·70	77·16	·52	1·94	80	81·10	64·88	7·69	6·15
13 & ½ of 12...	1	267¾	19·75	52·88	·53	1·42	52¼	83·50	43·63	7·57	3·96
	2	269	19·85	53·40	·51	1·37	54¼	83·40	45·24	5·68	3·08
Total ...	...	3,385	...	687·95	...	18·83	714	...	570·79	...	60·126
Average ...	...	...	20·32	...	0·56	...	...	79·94	...	8·42	...

TABLE No. I—*contd.*

Weight and composition of juice and jaggory (or massecuite) obtained from sugarcane plots. Plot IX.

Rows	Pan	Juice					Jaggory or Massecuite				
		Weight	Sucrose		Glucose		Weight	Sucrose		Glucose	
		lbs.	%	Total weight lbs.	%	Total weight lbs.	lbs.	%	Total weight lbs.	%	Total weight lbs.
1 and ½ of 2...	1	280	19·85	55·58	·41	1·15	55	85·00	46·75	5·49	3·02
	2	281⅓	20·00	56·30	·46	1·29	57½	81·70	46·98	7·46	4·29
3, 4 and ½ of 2	1	444⅔	20·40	90·73	·51	2·27	87	76·60	66·64	10·90	9·48
	2	352½	20·30	71·56	·44	1·55	72	86·40	62·21	4·50	3·24
5 and ½ of 6...	1	283¼	19·65	55·66	1·16	3·29	30	78·00	23·40	10·80	3·24
	2	...	...	...	...	...	26	67·65	17·59	12·13	3·15
½ of 6 and ½ of 7	1	Used for seed and other purposes.									
8, 9 and ½ of 7	1	369½	20·40	75·33	·60	2·22	75	78·00	58·50	9·20	6·90
	2	297½	20·35	60·49	·51	1·52	68	85·15	57·90	5·95	4·0
10, 11 & ½ of 12	1	401⅔	20·40	81·96	·32	1·29	81⅔	85·20	69·65	5·21	4·26
	2	365½	20·55	75·06	·35	1·28	76½	83·85	64·15	6·17	4·72
13 and ½ of 12	1	287	19·75	56·68	·31	0·89	59	89·10	52·57	2·53	1·49
	2	289½	20·00	57·90	·31	·90	59	88·60	52·27	3·70	2·18
Total ...	...	3,652	...	737·25	...	17·65	746¾	...	618·61	...	50·02
Average ...	...	...	20·19	...	0·48	...	...	82·84	..	6·70	...

Weight and composition of juice and jaggory (or massecuite) obtained from sugarcane plots. Plot X.

1 and ½ of 2...	1	274	20·00	54·80	·42	1·15	53¾	...	...	2·90	1·56
	2	204¾	20·05	41·05	·50	1·02	37¼	92·00	34·73	3·01	1·13
3, 4 and ½ of 2	1	334	21·50	71·81	·32	1·30	64½	85·50	55·15	5·10	3·29
	2	193	21·30	41·11	·39	0·75	40¼	84·00	33·81	4·24	1·71
5 to 9 southern third ...	...	118	21·05	24·84	·19	0·22	23	78·60	18·27	5·37	1·25
5 to 9 middle third ...	...	440	21·65	95·26	·38	1·67	103	78·60	80·96	7·28	7·50
5 to 9 northern third.	1	360½	20·10	72·41	·68	2·45	84	66·60	55·94	12·20	10·25
	2	217¼	20·25	43·99	·70	1·52	47¾	76·10	36·34	8·77	4·19
10, 11 and ½ of 12.	1	392	21·40	83·89	·46	1·80	86	81·80	70·35	6·85	5·89
	2	296	21·45	63·49	·50	1·48	64¼	85·20	54·74	4·80	3·08
13 and ½ of 12	1	291½	20·60	60·05	·49	1·43	63¾	84·30	53·74	5·88	3·75
	2	286¾	20·70	59·25	·46	1·32	62½	83·30	52·06	7·04	4·40
Total ...	...	3407	...	711·95	...	16·11	730¾	...	546·09	...	48·00
Average ...	...	...	20·90	...	0·47	...	...	74·73	...	6·57	...

TABLE No. I—*contd.*

Weight and composition of juice and jaggory (or massecuite) obtained from sugarcane plots. Plot XI.

Rows	Pan	Juice					Jaggory or massecuite				
		Weight	Sucrose		Glucose		Weight	Sucrose		Glucose	
		lbs	%	Total weight lbs	%	Total weigh lbs	lbs	%	Total weight lbs.	%	Total weight lbs.
1 and ½ of 2...	1	284¼	20·57	58·47	·41	1·17	49½	84·9	42·03	3·90	1·93
	2	229½	21·10	48·37	·41	0·94	44¾	88·2	39·47	2·94	1·31
3, 4 and ½ of 2	1	288½	21·05	60·73	·39	1·13	62	85·1	52·76	4·63	2·87
	2	245	21·35	52·31	·31	0·76	54¾	83·5	45·72	5·43	2·97
5 and ½ of 6 ...	...	322¾	21·20	68·42	·64	2·66	74¼	83·4	61·92	7·35	5·46
½ of 6 and ½ of 7	Used for seed and other purposes.										
8, 9 and ½ of 7	1	360¾	20·30	73·23	1·21	4·37	78½	84·8	66·57	4·70	3·69
	2	456½	20·75	94·72	.79	3.61	92¼	77·3	71·31	10·40	9·59
10, 11 & ½ of 12	1	472½	20·30	95·92	·62	2·93	102	80·8	82·42	6·48	6·61
	2	417½	20·75	86·63	·56	2·34	86	82·1	70·61	6·25	5·38
13 and ½ of 12	1	298¼	20·35	60·69	·42	1·25	60	85·25	51·15	4·70	2·82
	2	285	20·40	58·14	·45	1·28	574	84·2	48·41	3·60	2·07
Total ...	...	3,660¼	...	757·63	...	22·44	761½	...	632·37	...	44·70
Average ...	...	...	20·70	...	0·61	...	...	83·04	...	5·87	...

Weight and composition of juice and jaggory (or massecuite) obtained from sugarcane plots. Plot XII.

1 and ½ of 2...	1	247	20·40	50·39	·33	0·82	48½	82·6	39·85	4·67	2·25
	2	247¾	20·35	50·42	·42	1·04	52½	86·2	45·04	3·90	2·04
3, 4 and ½ of 2	1	297	21·70	64·45	·32	0·95	66½	84·3	56·06	4·71	3·13
	2	217½	21·65	47·09	·36	0·78	46¾	84·7	39·39	4·42	2·06
5 and ½ of 6 ...	...	297¾	21·65	64·46	·61	1·82	54¼	88·9	48·23	3·78	2·05
½ of 6 and ½ of 7	Used for seed and other purposes.										
8, 9 and ½ of 7	1	356¾	21·00	74·92	·69	2·46	75¾	79·8	60·45	8·77	6·64
	2	298½	20·95	62·48	·76	2·27	65½	82·5	53·83	6·41	4·18
10, 11 & ½ of 12	1	427½	21·50	91·91	·31	1·33	88½	81·1	71·77	7·24	6·41
	2	227	21·25	48·24	·43	0·98	45	84·5	38·03	5·74	2·58
13 and ½ of 12	1	284¼	20·75	58·98	·25	0·71	60¼	85·85	51·72	4·00	2·41
	2	268¾	20·65	55·50	·29	0·78	60	84·2	50·52	3·84	2·30
Total ...	...	3,169½	...	668·84	...	13·94	662½	...	554·89	...	36·05
Average ...	...	...	21·10	...	0·44	...	...	83·76	...	5·45	...

TABLE No. I—*contd.*

Weight and composition of juice and jaggory (or massecuite) obtained from sugarcane plots. Plot XIII.

Rows	Pan	Juice					Jaggory or massecuite				
		Weight	Sucrose		Glucose		Weight	Sucrose		Glucose	
		lbs.	%	Total weight lbs.	%	Total weight lbs.	lbs.	%	Total weight lbs.	%	Total weight lbs.
1 and ½ of 2...	1	258	20·60	53·15	·43	1·11	52¾	85·3	45·00	4·85	2·56
	2	210½	20·95	44·10	·33	0·69	45¼	86·0	38·06	3·90	1·73
3 4 and ½ of 2	1	298¾	21·15	63·19	·27	0·93	65½	87·2	57·12	2·90	1·90
	2	281½	21·00	59·12	·31	0·87	61¾	86·1	53·17	4·09	2·53
5 and ½ of 6...	...	299¾	21·20	63·55	·34	1·02	65¾	76·8	50·50	10·87	7·15
½ of 6 and ½ of 7	Used for seed and other purposes.										
8, 9 and ½ of 7	1	371¼	21·75	80·75	·36	1·34	84	78·0	65·52	4·76	4·00
	2	291	21·60	63·29	·65	1·89	68¾	75·4	51·84	6·41	4·41
10, 11 & ½ of 12	1	495¾	21·25	105·35	·43	2·13	100	85·1	85·10	3·75	3·75
	2	414	21·25	87·97	·44	1·82	86	82·9	71·29	6·25	5·37
13 and ½ of 12	1	295	20·55	60·62	·31	0·91	60¼	85·7	51·63	2·40	1·4
	2	395	20·80	82·16	·34	1·34	82¾	82·6	68·35	4·54	3·76
Total ...	...	3,610½	...	763·25	...	14·05	772¾	...	637·58	...	38·61
Average ...	...	...	21·14	...	0·39	...	...	82·51	...	4·00	...

Weight and composition of juice and jaggory (or massecuite) obtained from sugarcane plots. Plot XIV.

1 and ½ of 2.	1	253½	20·95	53·11	·32	0·81	52½	85·8	45·05	3·62	1·90
	2	186½	20·95	39·07	·41	0·76	37½	88·2	33·07	2·36	0·88
3, 4 and ½ of 2	1	292½	21·00	61·37	·25	0·73	62	85·3	52·87	3·78	2·34
	2	268¾	21·10	56·71	·26	0·70	56¾	85·0	48·24	4·50	2·55
5 and ½ of 6...	..	240¼	21·50	51·71	·38	0·91	47½	87·3	41·47	4·76	2·26
½ of 6 and ½ of 7	Used for seed and other purposes.										
8, 9 and ½ of 7	1	451½	21·20	95·72	·34	1·54	103¾	74·4	77·19	9·09	10·27
	2	159¾	21·50	34·35	·24	0·38	33½	81·7	27·37	4·09	1·37
10, 11 & ½ of 12	1	298	20·95	62·43	·32	0·95	55¾	83·9	46·77	6·66	3·71
	2	331	21·05	69·68	·30	0·99	65	82·5	53·62	6·66	4·33
13 and ½ of 12...	...	469	20·50	96·14	·21	0·98	102½	84·9	86·17	3·47	3·52
Total ...	...	2,950¾	...	620·29	...	8·75	616¾	...	511·82	...	33·13
Average ...	...	...	21·02	...	0·30	...	...	82·99	...	5·37	...

TABLE No. I—*concld.*

Weight and composition of juice and jaggory (or massecuite) obtained from sugarcane plots. Plot XV.

Rows	Pan	Juice					Jaggory or Massecuite				
		Weight	Sucrose		Glucose		Weight	Sucrose		Glucose	
		lbs.	%	Total weight lbs.	%	Total weight lbs.	lbs.	%	Total weight lbs.	%	Total weight lbs.
1 and ½ of 2.	1	261	21·0	54·81	·24	0·63	54¾	87·2	47·74	1·73	0·95
	2	229¾	20·90	48·02	·25	0·57	46½	88·1	40·97	2·08	0·97
3, 4 and ½ of 2	1	369¾	21·75	80·42	·32	1·18	83½	84·0	70·14	5·74	4·79
	2	203¼	21·60	43·90	·32	0·65	41¾	85·8	35·82	4·31	1·79
5 and ½ of 6 ...	...	334¼	20·75	69·36	·70	2·34	76	74·8	56·84	12·50	9·50
½ of 6 and ½ of 7		Used for seed and other purposes.									
8, 9 and ½ of 7	1	375¼	20·90	78·43	·77	2·89	88¾	72·1	63·99	9·26	8·22
	2	359½	20·75	74·60	·89	3·20	84½	78·0	65·91	6·33	5·35
10, 11 & ½ of 12	1	449	20·75	93·17	·60	2·69	90	84·0	75·60	6·75	6·07
	2	316½	20·55	65·04	·60	1·90	62	84·0	52·08	6·94	4·30
13 and ½ of 12	1	264¾	21·00	55·60	·48	1·27	54¾	88·4	48·40	2·60	1·42
	2	267¾	20·90	55·96	·46	1·23	55¾	87·1	48·56	3·93	2·19
Total ...	...	3430¾	...	719·31	...	18·55	738¼	...	606·05	...	45·55
Average	...	...	20·97	...	0·54	...	...	82·09	...	6·17	...

Weight and composition of juice and jaggory (or massecuite) obtained from sugarcane plots. Plot XVI.

1 and ½ of 2...	1	242¾	21·40	51·95	·38	0·92	50½	85·8	43·33	5·00	2·53
	2	349¼	21·05	73·52	·50	1·74	75¼	82·1	61·78	5·88	4·42
3, 4 and ½ of 2	1	374	21·45	80·44	·25	0·94	80¾	86·8	70·09	3·40	2·75
	2	357	21·05	75·15	·39	1·39	75¾	87·1	65·98	2·39	1·81
5 and ½ of 6 ...	...	336¾	20·75	69·88	1·04	3·50	67½	82·25	55·52	7·69	5·19
½ of 6 and ½ of 7		Used for seed and other purposes.									
8, 9 and ½ of 7	1	380¼	20·95	79·66	·70	2·66	81¼	73·05	59·35	7·46	6·06
	2	315¼	21·10	66·52	·62	1·94	78¾	68·70	54·10	13·70	10·79
10, 11 & ½ of 12	1	478	20·55	98·23	·61	2·92	87¾	83·65	73·40	5·32	4·69
	2	350¾	20·30	71·20	·94	3·30	65¾	86·25	56·71	4·38	2.88
13 and ½ of 12...	...	437	19·85	83·74	·56	2·45	86	86·50	74·39	4·80	4·13
Total ...	...	3,621	...	750·29	...	21·76	749¼	...	614·65	...	45·25
Average ...	...	...	20·72	...	0·60	...	...	82·04	..	6·04	..

TABLE No. II.

Total yield of sugarcane plots.

Number of plot	Weight of cane	Weight of tops	Weight of juice	Weight of begasse	Mark	Extraction	Juice				Percentage of juice left in begasse	Sucrose left in begasse	Total weight of sucrose produced	Yield of total cane sugar in percent above or below the average	Number of plot
							Sucrose		Glucose						
							Percent	Weight	Percent	Weight					
	lbs.	lbs.	lbs.	lbs.	percent	percent		lbs.		lbs.		lbs.	lbs.		
1	3,635	2,120	2,330	1,198¾	11·17	64·10	20·53	478·35	0·348	8·11	27·84	184	662	—24·67	1
2	4,194	2,170	2,699	1,305	10·13	64·35	20·55	554·64	0·289	7·80	28·40	219	774	—22·44	2
3	5,591	2,230	3,637	1,738	11·27	65·05	20·27	737·22	0·400	14·55	26·63	268	1,005	+0·07	3
4	5,885	2,120	3,805	1,934	10·49	64·66	20·45	778·12	0·403	15·33	27·76	299	1,077	+7·91	4
5	5,156	1,977	3,267	1,668	10·53	63·36	20·40	666·46	0·485	15·84	29·18	275	941	—5·71	5
6	5,256	2,169	3,354	1,758	10·96	63·81	20·27	679·86	0·421	14·12	28·34	269	949	—4·91	6
7	5,262	1,794	3,360	1,627	8·90	63·85	19·96	670·66	0·829	27·85	27·62	256	927	—7·11	7
8	5,606	2,043	3,655	1,748	10·06	65·20	20·32	742·70	0·556	20·32	27·51	282	1,025	+2·71	8
9	5,960	2,286	3,923	1,822	8·91	65·82	20·19	792·05	0·483	18·95	27·74	304	1,096	+9·82	9
10	5,383	1,975	3,407	1,794	11·27	63·29	20·90	712·06	0·473	16·12	28·67	286	998	0·00	10
11	5,947	1,977	3,894	1,922	10·93	65·48	20·70	806·06	0·613	23·87	27·61	307	1,113	+11·52	11
12	5,332	1,688	3,383	1,798	10·22	63·45	21·10	713·81	0·439	14·85	29·33	296	1,010	+1·20	12
13	5,948	2,194	3,853	1,927	10·23	64·78	21·14	814·52	0·389	14·99	27·84	314	1,129	+13·13	13
14	4,997	1,905	3,180	1,683	11·21	63·64	21·02	668·44	0·296	9·41	28·32	265	933	+6·51	14
15	5,726	2,074	3,656	1,904	10·93	63·85	20·97	766·66	0·540	19·74	28·31	302	1,069	+7·11	15
16	5,971	1,904	3,843	1,900	9·36	64·36	20·72	796·27	0·600	23·06	28·99	325	1,121	+12·32	16
Total...	85,849	32,626	55,246	27,726¾	166·57	1,029·05	329·49	11,377·88	7·564	264·91	450·09	4,451	15,829	.....	
Average	5,366	2,039	3,453	1,733	10·41	64·316	20·593	711·12	0·473	16·56	28·12	278·19 = 28·12%	989	.....	

TABLE No. III.

Loss of sugar by inversion, during boiling, when fully limed.

Plot	Juice		Fully limed jaggory and massecuite			Excess of Glucose in Jaggory, etc.	Lost in skimming, etc.		Sucrose decomposed	
	Sucrose	Glucose	Sucrose	Glucose	Glucose Ratio Glucose=1		Total sugar	Glucose		
	lbs.	lbs.	lbs.	lbs.		lbs.	lbs.	lbs.	lbs.	percent.
1	440·33	7·46	367·24	28·16	13·04	20·70	52·39	3·73	24·43	5·55
2	514·53	7·24	411·33	29·66	13·87	22·42	80·78	5·43	27·85	5·41
3	684·15	13·51	570·14	45·78	12·45	32·27	81·74	6·08	38·35	5·61
4	642·48	11·64	534·10	40·51	13·18	28·87	79·51	5·60	34·47	5·37
5	531·75	9·89	442·12	29·40	15·04	19·51	70·12	4·37	23·88	4·49
6	552·27	9·79	468·89	28·50	16·45	18·71	64·67	3·71	22·42	4·06
7	632·64	26·26	529·99	41·86	12·66	15·60	87·05	6·37	21·97	3·47
8	560·97	14·10	474·50	37·83	12·54	23·73	62·74	4·63	28.36	5·06
9	737·25	17·65	618·61	50·02	12·37	32·37	86·27	6·45	38·82	5·27
10	711·95	16·11	546·09	48·00	11·38	31·89	133·97	10·82	42·71	5·99
11	757·63	22·44	632·37	44·70	14·15	22·26	103·00	6·80	29·06	3·84
12	668·84	13·94	554·89	36·05	15·39	22·11	91·84	5·60	27·71	4·14
13	763·25	14·05	637·58	38·61	16·51	24·56	101·11	5·77	30·33	3·97
14	620·29	21·70	511·82	33·13	15·45	11·43	97·04	5·90	17·33	2·79
15	649·95	16·21	539·21	36·05	14·96	19·84	90·90	5·70	25·54	3·93
16	750·29	21·76	614·65	45·25	13·58	23·49	112·15	7·69	31·18	4·16
Total ...	10,218·57	243·75	8,453·53	613·51	.....	369·76	1,395·28	94·65	464·41	.....
Average...	.....	.....	.....	.....	13·78	.....	.....	.....	.....	4·54

Table No. IV.

Sugar boiled from juice treated with bhendi and soda.

No.	Juice contained		Massecuite boiled there-from contained		Total sugars lost by skimming, etc.	Ratio of glucose to sucrose in massecuite Glucose=1	Excess of glucose in massecuite over that in the juice	Glucose in skimmings	Percentage of sucrose inverted
	Sucrose lbs.	Glucose lbs.	Sucrose lbs.	Glucose lbs.					
696 ...	77·27	2·57	55·60	16·60	7·64	3·35	14·03	1·75	20·42
747 ...	75·40	3·25	49·80	19·76	9·09	2·52	16·51	2·58	25·33
795 ...	70·90	2·82	49·52	15·10	9·10	3·28	12·28	2·12	20·32
Total ...	223·57	8·64	154·92	51·46	25·83	3·01	42·82	6·45	22·03

Table No. IV—*concluded.*

Sugars boiled from juice treated with bhendi and soda.

Register No. of massecuite	Percentage of massecuite obtained in first sugar	Percentage of total sucrose obtained in first sugar	Percentage of sucrose in molasses	Glucose ratio in molasses	Color test with sugars Nesler			Sugar washed with water					Sugar washed with soap-nut decoction				
					Unwashed	Washed with water	Washed with soap-nut decoction	Weight of unwashed sugar	Water used for washing		Sugar lost by washing		Weight of unwashed sugar	Decoction used for washing		Sugar lost by washing	
									lbs.	%	lbs.	%		lbs.	%	lbs.	%
704	42·0	62·33	37·67	1·51	26	40	43	8·39	1·37	16·31	0·75	8·94	7·81	1·36	17·41	0·89	11·40
748	49·4	71·80	28·20	0·83	19	61	89	25·73	7·71	29·96	1·90	7·38	5·34	2·22	41·59	0·60	11·23
800	35·2	54·52	45·48	1·38	49	93	102	7·61	1·03	13·53	0·67	8·80	10·75	1·75	16·28	0·98	9·11
Total	...	...	...	...	...	...	...	41·73	10·11	...	3·32	...	23·90	5·33	...	2·47	...
Average	42·2	62·88	37·12	1·24	31	65	78	13·91	3·37	19·93	1·11	8·37	7·97	1·78	25·09	0·82	10·58

TABLE No. V.

Sugar boiled from juice fully limed.

No.	Juice		Massecuite		Total sugar lost in skimming	Ratio of glucose to sucrose in massecuite Glucose = 1	Excess of glucose in massecuite over that in juice lbs.	Glucose lost in skimming lbs.	Percentage of sucrose decomposed
	Sucrose in lbs.	Glucose in lbs.	Sucrose in lbs.	Glucose in lbs.					
625 ...	45·90	1·09	35·94	3·81	7·24	9·43	2·72	0·69	7·43
643 } ...	130·42	1·85	93·73	9·70	28·84	9·66	7·85	2·70	8·09
644 }									
672 ...	79·00	3·09	58·06	7·12	16·91	8·15	4·03	1·85	7·44
725 ...	73·62	4·50	55·85	9·51	12·76	5·87	5·01	1·86	9·33
773 ...	42·61	2·91	31·94	5·23	8·35	6·11	2·32	1·17	8·19
847 ...	24·84	0·22	16·31	1·11	7·64	14·69	0·89	0·48	5·52
848 ...	95·26	1·67	76·73	7·11	13·09	10·79	5·44	1·11	6·88
928 } ...	144·04	3·23	101·52	6·96	38·79	14·59	3·73	2·49	4·32
929 }									
952 } ...	130·07	1·92	96·59	6·67	28·73	14·48	4·75	1·86	5·08
953 }									
979 ...	78·43	2·89	59·32	7·62	14·38	7·78	4·73	1·64	8·12
980 ...	74·60	3·20	60·93	4·94	11·93	12·33	1·74	0·89	3·53
Total ...	918·79	26·57	686·92	69·78	188·66	9·844	43·21	16·74	6·52

TABLE No. V—*concluded.*

Sugars boiled from juice fully limed.

Number	In massecuite		In unwashed sugar		Percentage of massecuite obtained as first sugars	Percentage of sucrose obtained as first sugars	Glucose ratio in molasses	Depth of color of sugar in Nesler tube			Washed with water					Washed with soap-nut decoction				
								Unwashed	Washed with		Weight of unwashed sugar	Sugar lost in washing		Water used		Weight of unwashed sugar	Sugar lost in washing		Water used	
	Sucrose	Glucose	Sucrose	Glucose					Water	Soap-nut decoction		lbs	%	lbs	%		lbs	%	lbs	%
626	35·94	3·81	26·03	0·35	57·80	72·43	2·78	38	66	66	5·31	0·50	9·42	0·27	5·08	10·84	1·25	11·53	0·62	5·72
649	93·73	9·70	52·48	0·53	42·46	55·98	3·94	48	79	77	18·14	0·95	5·24	0·86	4·74	18·31	1·42	7·76	0·71	3·88
675	58·06	7·12	39·76	0·56	52·86	68·48	2·86	28	42	34	10·23	1·23	12·02	1·11	10·85	17·17	1·98	11·53	1·02	5·94
726	55·85	9·51	34·98	0·65	47·78	62·63	2·26	28	32	31	10·22	1·08	10·57	0·65	6·36	11·05	1·67	15·11	0·87	7·87
774	31·94	5·23	21·05	0·37	49·51	65·90	2·32	38	87	130	8·75	1·08	12·33	0·81	9·26	2·97	0·85	28·62	0·50	16·84
827	16·55	2·97	10·01	0·24	42·54	60·48	2·38	26	30	...	2·38	0·32	13·45	0·50	2·10	...	...	...	...	...
858	16·31	1·11	10·78	0·09	52·91	66·09	5·72	36	42	58	3·82	0·57	14·92	0·44	11·52	3·44	0·50	14·55	0·21	6·10
863	76·73	7·11	54·61	1·19	58·03	71·17	3·68	28	98	146	12·56	1·59	12·66	0·86	6·85	35·58	6·44	18·10	2·39	6·72
934	101·52	6·96	71·36	1·76	57·38	70·29	5·20	40	55	...	22·17	1·34	6·04	1·00	4·51	...	...	...	...	...
958	96·59	6·67	68·73	1·26	57·26	71·16	3·20	36	56	66	25·34	2·11	8·33	1·14	4·50	15·50	1·89	12·19	0·78	5·03
983	59·32	7·62	37·33	0·69	46·97	62·93	3·56	52	109	135	15·17	1·62	10·68	0·90	5·93	8·94	1·52	17·00	0·69	7·72
988	60·93	4·94	39·30	0·77	52·24	64·50	4·68	27	80	88	11·06	1·29	11·66	0·84	7·59	10·67	1·62	15·18	1·03	9·65
Average	58·62	6·062	38·87	0·705	51·48	66·003	3·55	35	64·7	83·1	12·09	1·14	9·43	0·78	6·45	13·44	1·914	14·24	0·882	6·56

Table No. VI.

Composition of juice from cane cut during different weeks of the harvest season. Cane cut during the first week (25th February 1907 to 3rd March 1907).

No. of Sample	Sucrose %	Glucose %	Total Solids %	Date when cut	No. of Sample	Sucrose %	Glucose %	Total Solids %	Date when cut
				1907					1907
613	19·85	·30	20·32	25th February	837	20·70	·46	21·38	28th February
631	20·55	·18	21·12	25th February	868	20·57	·41	21·25	2nd March
654	20·15	·18	20·44	25th February	870	21·10	·41	21·52	2nd March
680	20·35	·22	20·72	26th February	872	20·35	·42	21·05	28th February
709	20·10	·23	21·77	28th February	874	20·40	·45	21·25	28th February
731	20·30	·24	21·32	28th February	894	20·75	·25	21·44	28th February
733	19·35	·51	20·38	2nd March	896	20·65	·29	21·24	28th February
753	19·85	·58	21·60	28th February	912	20·55	·31	20·99	26th February
755	20·25	·63	21·20	28th February	914	20·80	·34	21·27	26th February
757	19·25	·57	20·31	2nd March	938	20·50	·21	20·98	26th February
759	19·85	·54	20·60	2nd March	963	21·00	·48	21·65	25th February
779	19·50	·49	20·58	1st March	965	20·90	·46	21·78	25th February
781	19·90	·46	20·58	1st March	993	19·85	·56	20·46	25th February
783	19·75	·53	20·71	1st March					
785	19·85	·51	20·91	1st March					
831	20·00	·42	20·86	2nd March					
833	20·05	·50	20·44	2nd March					
835	20·60	·49	21·58	28th February	Average	20·25	0·41	21·02	

Cane cut during the second week (4th March 1907 to 10th March 1907).

616	20·40	·31	20·99	6th March 1907	918	20·95	·33	21·24	5th March 1907
618	20·50	·29	21·11	7th March 1907	920	21·15	·27	21·49	9th March 1907
620	20.50	·26	21·11	7th March 1907	922	21·00	·31	21·37	9th March 1907
633	19·95	·29	20·71	6th March 1907	940	20·95	·32	21·98	5th March 1907
635	20·80	·24	21·67	7th March 1907	942	20·95	·41	21·65	5th March 1907
637	20·85	·24	21·39	7th March 1907	944	21·00	·25	21·18	8th March 1907
656	20·05	·32	21·12	5th March 1907	946	21·10	·26	21·45	8th March 1907
658	19·75	·37	20·85	5th March 1907	967	21·00	·24	21·24	6th March 1907
660	20·15	·33	20·71	8th March 1907	969	20·90	·25	21·52	6th March 1907
662	20·10	·41	20·78	8th March 1907	971	21·75	·32	22·07	7th March 1907
664	20·35	·32	21·39	8th March 1907	973	21·60	·32	21·98	7th March 1907
682	20·25	·36	21·18	5th March 1907	995	21·40	·38	21·87	6th March 1907
684	20·45	·32	20·98	5th March 1907	997	21·05	·50	21·87	6th March 1907
686	20·65	·34	21·11	9th March 1907	999	21·45	·25	21·78	7th March 1907
688	20·50	·36	21·11	9th March 1907	1001	21·05	·39	21·65	7th March 1907
711	20·15	·30	20·44	4th March 1907					
713	20·75	·47	21·72	9th March 1907					
715	20·85	·39	21·52	9th March 1907					
890	20·40	·33	20·64	4th March 1907					
892	20·35	·42	20·91	4th March 1907					
898	21·70	·32	22·79	9th March 1907	Average	20·76	0·33	21·37	
900	21·65	·36	22·27	9th March 1907					
916	20·60	·43	21·31	5th March 1907					

TABLE No. VI—*contd.*

Composition of juice from cane cut during different weeks of the harvest season.

Cane cut during the third week (11-3-07 to 17-3-07)					Cane cut during the fourth week (18-3-07 to 24-3-07)				
No. of Sample	Sucrose %	Glucose %	Total Solids %	Date when cut	No. of Sample	Sucrose %	Glucose %	Total Solids %	Date when cut
690	20·80	·35	21·72	16th Mar. 1907	622	20·75	·28	21·72	
792	20·50	·43	21·39	16th ,, 1907	639	20·45	·34	21·12	19th March 1907
717	20·95	·23	21·87	14th ,, 1907	641	20·25	·41	21·19	19th ,, 1907
719	20·75	·29	21·67	14th ,, 1907	666	20·45	·37	21·45	18th ,, 1907
735	20·40	·36	21·17	11th ,, 1907	668	20·50	·28	21·19	18th ,, 1907
737	20·25	·36	21·11	11th ,, 1907	948	20·95	·32	21·51	18th ,, 1907
739	20·50	·32	21·17	14th ,, 1907	950	21·05	·30	21·65	18th ,, 1907
741	20·50	·33	21·24	14th ,, 1907	975	20·75	·60	21·72	19th ,, 1907
761	21·00	·64	22·07	11th ,, 1907	977	20·55	·60	21·72	19th ,, 1907
763	20·95	·65	21·99	11th ,, 1907	1003	20·55	·61	21·65	20th ,, 1907
765	20·55	·64	21·53	13th ,, 1907	1005	20·30	·94	21·65	20th ,, 1907
767	20·55	·71	21·67	13th ,, 1907					
787	20·65	·45	21·24	12th ,, 1907					
789	20·70	·52	21·71	12th ,, 1907					
791	20·55	·44	21·58	13th ,, 1907					
793	20·95	·49	21·71	13th ,, 1907					
839	21·50	·32	22·05	11th ,, 1907					
841	21·30	·39	22·13	11th ,, 1907					
843	21·40	·46	22·07	13th ,, 1907	Average	20·60	0·459	21·506	
845	21·45	·50	22·27	13th ,, 1907					
876	21·05	·39	21·58	11th ,, 1907					
878	21·35	·31	21·78	11th ,, 1907					
880	20·30	·62	21·24	14th ,, 1907					
882	20·75	·56	21·85	14th ,, 1907					
902	21·50	·31	22·22	14th ,, 1907					
904	21·25	·43	21·92	14th ,, 1907					
924	21·25	·43	21·98	16th ,, 1907					
926	21·25	·44	22·05	16th ,, 1907					
Average	20·89	0·44	21·71						

TABLE No. VI—*concld.*

Composition of juice from cane cut during different weeks of the harvest season.

Cane cut during the seventh week (8-4-07 to 14-4-07)					Cane cut during the eighth week (15-4-07 to 21-4-07)				
No. of Sample	Sucrose %	Glucose %	Total Solids %	Date when cut	No. of Sample	Sucrose %	Glucose %	Total Solids %	Date when cut
624	21·05	·46	21·85	9 April 1907	694	21·10	·47	22·07	15 April 1907
643	21·25	·31	21·72	10 ,, 1907	695	20·85	·53	21·72	15 ,, 1907
644	21·15	·29	21·79	10 ,, 1907	721	20·35	·50	21·39	16 ,, 1907
670	20·85	·40	21·72	12 ,, 1907	723	20·60	·58	21·49	16 ,, 1907
671	20·75	·57	21·79	12 ,, 1907	743	21·00	·31	21.91	17 ,, 1907
847	21·05	·19	21·78	11 ,, 1907	745	20·75	·46	21·65	17 ,, 1907
848	21·65	·38	22·65	11 ,, 1907	769	20·50	·84	21·85	18 ,, 1907
849	20·10	·68	21·12	11 ,, 1907	771	16·10	2·16	18·87	18 ,, 1907
850	20·25	·70	21·19	11 ,, 1907	773	19·75	1·35	21·79	20 ,, 1907
952	21·20	·34	22·05	12 ,, 1907	795	20·10	·80	21·24	20 ,, 1907
953	21·50	·24	22·12	12 ,, 1907	796	20·50	·67	21·58	20 ,, 1907
979	20·90	·77	22·12	10 ,, 1907	798	20·60	·70	21·65	20 ,, 1907
980	20·75	·89	22·19	10 ,, 1907	884	20·30	1·21	21·78	17 ,, 1907
1007	20·95	·70	22·05	9 ,, 1907	886	20·75	·79	21·85	17 ,, 1907
1008	21·10	·62	22·05	9 ,, 1907	906	21·00	·69	22·05	16 ,, 1907
					908	20·95	·76	22·05	16 ,, 1907
					928	21·75	·36	22·47	15 ,, 1907
					929	21·60	·65	22·47	15 ,, 1907
Average	20·96	0·50	21·88		Average	20·475	·77	21·66	

TABLE No. VI—*concld.*

Composition of juice from cane cut during different weeks of the harvest season. Cane cut during the ninth week, (22nd April 1907 to 28th April 1907).

Number of sample	Sucrose %	Glucose %	Total Solids %	Date when cut
625	20·20	·48	20·99	.....
645	19·75	·32	20·44	.....
672	19·70	·77	21·08	24th April 1907.
696	19·55	·65	20·98	Do
725	19·95	1·22	20·96	23rd April 1907.
747	19·70	·85	20·58	Do
888	21·20	·64	22·05	Do
910	21·65	·61	22·27	Do
930	21·20	·34	22·05	24th April 1907.
954	21·50	·38	22·41	Do
981	20·75	·70	22·05	25th April 1907.
1009	20·74	1·04	22·16	Do
Average ...	20·49	0·66	21·50	

Table No. VII.

Composition of juice from two varieties of cane planted on February 22nd 1906 and cut on different dates showing changes during ripening process.

Date of cutting	Variety No. 1			Variety No. 2		
	Sucrose %	Glucose %	Total Solids %	Sucrose %	Glucose %	Total Solids %
20th October 1906 ...	18·35	·74	19·50	13·00	1·90	15·30
27th October 1906 ...	17·00	·60	17·90	12·90	2·09	15·44
3rd November 1906 ...	17·50	·74	19·08	12·30	2·13	15·02
12th November 1906...	18·90	·55	20·05	14·05	1·40	16·07
19th November 1906...	20·35	·32	21·10	14·50	1·61	16·77
26th November 1906...	20·60	·27	21·25	14·30	1·35	16·17
3rd December 1906 ...	20·60	·17	21·30	15·90	1·56	17·84
10th December 1906...	20·95	·16	21·38	15·25	1·70	17·03
17th December 1906...	20·15	·15	21·00	17·95	1·01	19·10
24th December 1906...	20·75	·12	21·49	18·70	0·86	19·84
4th January 1907 ...	20·85	·089	21·37	18·00	0·87	18·84
12th January 1907 ...	21·25	·097	21·49	19·75	0·47	20·58
19th January 1907 ...	21·05	·10	21·64	18·95	0·70	19·84
26th January 1907 ...	21·40	·12	21·78	18·20	0·69	19·23
2nd February 1907 ...	21·30	·12	21·85	...	...	...
9th February 1907 ...	...	...	...	18·90	0·33	...
21st March 1907 ...	20·10	·095	20·98	17·75	0·67	19·30

Table No. VIII.

Showing the composition of different parts of sugar cane.

Substance		Weight of Substance when cane was cut gr.	Weight when analysed gr.	Lime Cao %	Nitrogeon %	Phospho. ric acid %	Potash %
Tops	Juice...	600	600	0·038	0·053	0·099	0·41
	Begasse	1,142	379	0·143	0·250	0·340	1·21
Green leaves ...		1,700	605	0·280	0·460	0·240	1·25
Dead leaves ...		757	706	0·390	0·048	0·096	0·41
Cane	Juice...	4,947	4,947	0·021	0·0089	0·073	0·107
	Begasse	2,548	1,096	0·108	0·240	0·142	0·246

Table No. IX (Calculated).

Composition of various parts of cane in natural stage.

Substance	Cane when cut		Lime %	Nitrogen %	Phosphoric acid %	Potash %
	Weight gr.	%				
Tops ...	1,742	14·90	·04414	·07261	·1081	·4044
Green leaves ...	1,700	14·54	·09965	·16370	·0854	·4448
Dead leaves ...	757	6·47	·36380	·04478	·0895	·3823
Cane ...	7,495	64·09	·02964	·04096	·0689	·1065
Total Cane ...	11,694	100·00	·06361	·06376	·0785	·2179

Table No. X (Calculated).

Weight of different parts of cane per acre and of the plant food removed by them per acre.

Substance	Weight of parts as harvested lbs.	Lime lbs.	Nitrogen lbs.	Phosphoric acid lbs.	Potash lbs.
Tops ...	12,988	5.73	9·43	14·04	52·52
Green leaves	12,674	12·63	20·77	10·82	56·37
Dead leaves ...	5,644	20·53	2·53	5·05	21·58
Cane ...	55,879	16·56	22·89	38·50	59·51
Total ...	87,185	55·45	55·62	68·41	189·98

Table No. XI.

Effect of cultivation on soil moisture.

Sample	Preliminary sample	Surface soil		Surface soil		Surface soil		Surface soil		Surface soil		
		Cultivated 1½″ deep	(rolled) Uncultivated	Cultivated 1½″ deep	Uncultivated	Cultivated 1½″ deep	Uncultivated	Cultivated 1½″ deep	Uncultivated	Cultivated 1½ feet deep	Cultivated 1½″ deep	Uncultivated
Date	14-10-06	1-11-06	2-11-06	14-11-06	15-11-06	28-11-06	28-11-06	15-12-06	15-12-06	20-12-06	21-12-06	21-12-06
Rainfall in inches since last sample was taken		·97		·56		·08		·10			·54	
Date				6 and 7		22 and 23		6 and 8			19 and 20	
	Water%	Water%	Water%	Water%	Water%	Water%	Water%	Water%	Water%	Water%	Water%	Water%
From surface to 1½ in.	10·22	6·25	5·38	6·19	5·60	4·58	4·49	5·16	4·34	8·60	8·63	7·09
1½ in. to 3 in.										7·85	8·17	7·72
3 in. to 4½ in.										7·67	8·02	7·58
4½ in. to 6 in.										6·82	8·18	6·86
6 in. to 7½ in.	12·15	12·19	12·03	12·62	10·50	10·92	9·75	11·38	9·97	7·30	10·85	8·78
7½ in. to 9 in.												
9 in. to 10½ in.												
10½ in. to 1 ft.										7·16	11·07	11·44
1 ft. 0 in. to 1 ft. 3 in.	14·20	12·97	13·88	13·25	12·74	12·21	12·24	11·90	12·29	9·33	11·89	11·86
1 ft. 3 in. to 1 ft. 6 in.										12·44	12·33	11·54
1 ft. 6 in. to 1 ft. 9 in.	14·68	12·97	14·11	12·99	12·35	12·82	12·61	12·62	12·78	12·80	12·44	11·41
1 ft. 9 in. to 2 ft. 0 in.										12·88	12·58	11·99
2 ft. 0 in. to 2 ft. 3 in.	14·72	13·78	13·80	12·77	12·88	13·12	12·97	12·78	13·17	12·65	12·43	12·92
2 ft. 3 in. to 2 ft. 6 in.										13·06	12·17	11·95
2 ft. 6 in. to 2 ft. 9 in.	14·60	12·61	13·33	13·25	13·07	13·10	13·01	13·09	13·30	12·14	11·61	13·00
2 ft. 9 in. to 3 ft. 0 in.										12·67	11·04	13·27
3 ft. 0 in. to 3 ft. 3 in.	14·55	13·42	13·40	13·89	13·33	13·37	13·13	13·65	12·88	13·21	11·79	13·47
3 ft. 3 in. to 3 ft. 6 in.												
3 ft. 6 in. to 3 ft. 9 in.	14·77	13·42	13·28	13·75	13·52	13·84	13·12	13·42	13·00	13·18	11·96	12·59
3 ft. 9 in. to 4 ft. 0 in.												
4 ft. 0 in. to 4 ft. 3 in.	14·67	13·84	13·86	13·21	12·91	13·58	12·74	13·67	12·50	13·14	12·14	13·00
4 ft. 3 in. to 4 ft. 6 in.												
4 ft. 6 in. to 4 ft. 9 in.	15·02	13·86	13·52	13·58	13·14	13·25	12·87	13·33	12·90	13·16	12·41	13·07
4 ft. 9 in. to 5 ft. 0 in.												
5 ft. 0 in. to 5 ft. 3 in.	14·85	13·93	13·45	13·29	12·98	13·52	13·06	13·46	12·89	12·64	12·67	12·98
5 ft. 3 in. to 5 ft. 6 in.												
5 ft. 6 in. to 5 ft. 9 in.	14·69	...	13·57	13·16	12·98	13·24	12·91	12·99	12·90	11·68	12·96	13·56
5 ft. 9 in. to 6 ft. 0 in.												

TABLE No. XI—*concld.*

Effect of cultivation on soil moisture.

Sample	Surface soil			Surface soil			Surface soil			
	Cultivated 1½ feet deep	Cultivated 1½ inches deep	Uncultivated	Cultivated 1½ feet deep	Cultivated 1½ inches deep	Uncultivated	Under Bengal gram	Cultivated 1½ feet deep	Cultivated 1½ inches deep	Uncultivated
Date	4th Jan. 07	3rd Jan. 07	3rd Jan. 07	18th Jan. 07	17th Jan. 07	17th Jan. 07	5th Feb. 07	4th Feb. 07	4th Feb. 07	6th Feb. 07
Rainfall since last sample was taken		·51			·95					
Date		21, 28, 29 & 31			10 & 11					
	Water %	Water %	Water %	Water %	Water %	Water %	Water %	Water %	Water %	Water %
From surface to 1½″	6·06	4·14	2·70	2·84	4·49	2·43	1·02	1·77	1·92	1·60
,, 1½″ ,, 3″	4·72	5·54	5·43	7·52	6·69	5·28	2·47	4·81	4·54	2·93
,, 3″ ,, 4½″	5·99	7·28	6·37	8·66	7·39	6·50	3·92	4·95	5·56	3·90
,, 4½″ ,, 6″	5·36	6·92	6·24	7·56	9·00	7·07	2·96	6·31	6·82	4·56
,, 6″ ,, 7½″	7·74	10·79	8·15	10·09	11·84	9·68	3·85	7.62	8·51	7·76
,, 7½″ ,, 9″							6·59			
,, 9″ ,, 10½″	9·94	11·72	11·56	13·16	11·88	11·65	8·71	8·79	9·04	9·17
,, 10½″ ,, 1 foot									Stones	
,, 1 feet ,, 1′3″	11·58	12·16	11·77	13·25	11·88	11·66	8·98	11·58	10·82	10·04
,, 1′3″ ,, 1′6″	12·45	12·27	11·67	12·33	11·97	12·11	9·04	12·70	12·44	10·24
,, 1′6″ ,, 1′9″	12·07	11·36	11·80	11·54	12·53	12·65	8·30	12·12	12·89	11·57
,, 1′9″ ,, 2′0″	12·60	12·31	12·09	12·43	12·63	12·30	8·54	12·19	12·37	11·89
,, 2′0″ ,, 2′3″	12·54	12·57	12·44	12·60	12·80	12·62	9·46	11·62	12·46	11·80
,, 2′3″ ,, 2′6″	12·84	12·92	12·00	12·85	13·03	12·32	8·91	12·11	12·66	11·94
,, 2′6″ ,, 2′9″	13·24	12·18	12·23	12·83	12·87	11·64	9·16	12·39	12·77	12·06
,, 2′9″ ,, 3′0″	13·20	12·90	12·50	13·06	12·99	12·57	8·94	12·45	12·86	11·83
,, 3′0″ ,, 3′3″	12·84	12·88	13·04	13·20	12·93	13·05	8·75	13·04	13·08	11·91
,, 3′3″ ,, 3′6″										
,, 3′6″ ,, 3′9″	.....	13·41	12·67	12·83	13·05	12·64	9·36	12·93	12·47	12·52
,, 3′9″ ,, 4′0″							9·09			
,, 4′0″ ,, 4′3″	13·12	13·39	12·89	.....	12·67	12·61	9·68	12·94	12·90	12·82
,, 4′3″ ,, 4′6″							9·88		13·01	
,, 4′6″ ,, 4′9″	13·24	12·15	12·97	13·87	13·23	12·27	10·59	13·09	12·95	12·94
,, 4′9″ ,, 5′0″							10·40			
,, 5′0″ ,, 5′3″	12·74	12·98	13·23	.....	13·04	12·15	11·48	12·13	12·56	12·40
,, 5′3″ ,, 5′6″							10·80			
,, 5′6″ ,, 5′9″	12·15	12·50	12·97	12·07 Gravelly	12·58	12·91	10·11	11·23	12·35	12·83
,, 5′9″ ,, 6′0″										

Table No. XII.

Rainfall Register from October 1906—March 1907.

Date		Rainfall in inches
October	3rd	1·48
	5th	0·28
	6th	0·56
	7th	0·43
	8th	0·75
	9th	0·28
	10th	0·14
	11th	0·53
	12th	0·99
	14th	0·44
Before 1st boring	...	5·88
October	15th	0·05
	17th	0·27
	18th	0·07
	20th	0·06
	25th	0·02
	26th	0·06
Between 1st and 2nd borings	...	0·53
November	6th	0·39
	7th	0·17
	15th	0·01
Between 2nd and 3rd borings	...	0·57
November	22nd	0·03
	23rd	0·05
Between 3rd and 4th borings	...	0·08
December	6th	0·01
	8th	0·09
Between 4th and 5th borings	...	0·10
December	19th	0·02
	20th	0·52
	21st	0·01
Between 5th and 6th borings	...	0·55
December	28th	0·08
	29th	0·29
	31st	0·13
Between 6th and 7th borings	...	0·50
January	10th	0·80
	11th	0·15
Between 7th and 8th borings	...	0·95
Between 8th and 9th borings	...	0·00

Table No. XIII.

Composition of "Famine Foods."

No.	Local name	Moisture %	Nitrogen. %	Proteids. %	Fat %	Crude fibre. %	Carbohydrates %	Ash insoluble in weak acids or alkalies. %
137	Navare Genasu	8·76	0·86	5·37	0·71	4·45	79·80	0·93
138	Sal do	11·11	1·31	8·18	0·76	4·64	74·40	0·97
139	Karane do	8·93	1·58	9·87	1·43	14·30	65·10	1·00
140	Kall do	8·10	1·08	6·75	1·76	5·28	77·85	0·68
141	Akki do	8·26	1·09	6·81	1·60	4·36	79·36	0·32
142	Adavi do	8·96	1·17	7·31	1·76	3·48	78·80	0·46
143	Nose Gadde	10·28	1·79	11·18	1·12	2·62	74·22	0·56
144	Kathale Gadde	7·96	0·67	4·18	0·45	3·01	84·30	0·06
146	Bettada Eachal Hannu (wild-date)	9·24	0·63	3·93	0·75	10·29	74·77	0·90
148	Kare soppu	6·77	2·27	14·18	3·14	15·14	59·53	...
149	Kesavina Gaddé	6·16	0·91	5·68	0·92	9.99	77·23	...
150	Maragenasu (Tapioca) ...	3·14	0·60	3·75	1·91	7·05	83·75	...
151	Attikayi	10·85	1·21	7·56	4·10	15·45	61·66	0·36
152	Yele Genasu	6·64	1·48	9·25	2·03	14·81	65·32	1·98
153	Honagone soppu	6·10	3·07	19·18	1·72	15·63	53·47	...
159	Bidaru Kalalay	10·02	4·23	26·43	1·48	12·77	49·32	...
162	Noren Genasu	5·70	0·80	5·00	1·90	10·57	74·19	2·60
164	Byle do	9·89	0·72	4·50	2·06	10·67	69·73	3·10
169	Pine apple fruits	9·72	1·08	6·75	0·34	8·58	74·26	0·20
170	Gudugudi fruits	8·54	0·51	3·18	0·54	8·61	78·41	0·60
171	Chelvi Genasu	5·68	1·65	10·31	0·64	9·91	71·87	1·50

Table No. XIV.

"Famine Foods" *(partially analysed).*

No.	Local name	Nitrogen. %	No.	Local name	Nitrogen. %
134	Gutti Gaddé ...	2·86	178	Kadu Nugge soppu ...	2·18
135	Bendle soppu... ...	1·95	179	Kadu Haruve soppu ...	1·51
136	Devadari soppu ...	1·83	186	Navale bhatta ...	1·64
147	Jambu-Nérale kayi ...	0·82	209	Hedige Genasu ...	2·11
154	Vishnukranthi soppu ...	2·22	210	Bagani pith	0·06
155	Hunisé beeja ...	2·34	216	Anne soppu	2·44
156	Thangadi huvu ...	1·47	224	Bidaru Akki	1·80
157	Kesavina dantu ...	1·05	226	Pundi soppu	3·33
158	Chandra Malligé Gaddé ...	1·03	230	Akki thowdu	1·57
160	Vondalaga soppu ...	1·53	253	Bongari kayi	0·69
161	Kondal Genasu ...	0·82	254	Chagachi soppu ...	2·32
163	Seebe Gaddé ...	1·12	259	Kayi Genasu	1·27
165	Bikki kayi ...	0·68	268	Kadu Ragi	2·65
166	Makali béru ...	0·40	270	Soft stem of country date	0·84
167	Goni hannu ...	1·16	271	Babul seeds	6·06
168	Alada hannu ...	0·92	273	Lotus roots	1·77
172	Kavali Genasu ...	1·37	277	Deva Genasu	1·18
173	Noori do ...	1·63	323	Agase soppu	4·67
174	Noolina do ...	1·61	375	Navare hannu ...	2·00
175	Godirasanidha Gaddé Hittu	0·05	349	Tupre do	0·26
176	Kannay soppu ...	2·70	385	Seege soppu	4·97
177	Marakesavina Gaddé ...	1·34	386	Hunisé soppu... ...	1·83

Table No. XV.

List of "Famine Foods."

No.	Local name	English name	Botanical name	District	Remarks
134	Gutti gadde ...	.....	.....	Kolar	The tubers are boiled with dhal and eaten mixed with salt. Delicate persons are said to develop rheumatism if they eat this food.
135	Bendli soppu ...	Bastard sandal	Erythroxylon monogynum.	,,	The leaves are dried and boiled in water with salt.
136	Devadari or gyadari soppu.	Commonly known as the beal tree	Ægle marmelos ...	,,	The leaves are dried, ground, mixed with Ragi flour and cooked.
137	Navare genasu ...	.....	.....	Mysore	Eaten fried or boiled said to produce cough.
138	Sal genasu ...	.....	.....	,,	
139	Karane genasu ...	.....	.....	,,	
140	Kall genasu ...	.....	.....	,,	
141	Akki genasu ...	.....	.....	,,	
142	Adavi genasu ...	Species of yams	Dioscorea ...	Bangalore	
143	Nose gadde ...	.....	.....	Kolar	The tuber is ground, mixed with tamarind and made into cakes.

TABLE No. XV—*contd.*

List of "Famine Foods."

No.	Local name	English name	Botanical name	District	Remarks
144	Kathale gadde ...	Aloe roots ...	Agave Americana...	Kolar.	The soft portion is cut into pieces, boiled with a paste of tamarind, dried in the sun and eaten.
145	Eachal hannu ...	Date fruits ...	Phoenix sylvestrius.	,,	
146	Bettada Eachal hannu	Do ,, ...	Phoenix farinifera...	,,	
147	Jambu Neralay kayi	.....	Eugenia jambulona. Var. obtusifolia.	,,	
148	Kare soppu ...	.....	Canthium parniflorum.	,,	
149	Kesavina gadde ...	.....	Alacacia antiquorum	Tumkur.	
150	Mara genasu ...	Tapioca ...	Manihot utillisima...	,,	
151	Atti kayi ...	Country fig ...	Ficus glomerata ...	,,	Cooked and eaten; or dried ground and mixed with Ragi flour and boiled and eaten.
152	Yele genasu ...	.....	Dioscorea species...	Mysore	
153	Honagonne soppu ...	.....	Alternanthera sessilis.	Kolar	
154	Vishnukranthi soppu	.....	Evolvulus alsinoides.	,,	

155	Hunise beeja ...	Tamarind seeds.	.....	Kolar.	Seeds fried, husks removed, the cotyledons broken into pieces, boiled and eaten.
156	Thangadi huvu ...	.....	Cassia auriculata ...	Tumkur	
157	Kesavina dhantu ...	.....	Alacacia antiquorum	,,	
158	Chandramallige gadde	.....	Mirabilis jalapa ...	Hassan	
159	Bidaru kalalay ...	Bamboo shoots.	Bambusa aurundinacea.	,,	
160	Vondalaga soppu ...	.....	Hydrocotyle Asiatica	,,	
161	Kondal genasu ...	.....	.....	,,	
162	Noren genasu ...	.....	Dioscorea aculeata...	,,	Eaten boiled.
163	Seebe gadde ...	.....	.....	,,	
164	Byle genasu ...	.....	Dioscorea species ...	,,	
165	Bikki kayi ...	.....	Gardenia gummifera.	,,	
166	Makali beru ...	.....	.....	,,	
167	Goni hannu ...	.....	Ficus Mysorensis ...	Kadur	
168	Alada hannu ...	Banyan fruit...	Ficus Bengalensis...	,,	
169	Ananas hannu ...	Pine apple ...	.....	Hassan	
170	Gudu gudi fruits ...	.....	Scutia Indica ...	,,	
171	Chelvi genasu ...	.....		Mysore	
172	Kavali genasu ...	.....	.....	,,	Eaten raw.
174	Noolina genasu ...	.....	.....	Mysore	
175	Goddirasanida gadde.	.....	.....	Shimoga	
176	Kannay soppu ...	.....	Commelyna communis.	Kolar	
177	Marakesavina gadde.	.....	Alocacia species ...	Mysore	
178	Kadu nugge soppu...	.....	.....	,,	
179	Kadu haruve soppu.	.....	Embelia ribes ...	,,	

TABLE XV—*contd.*

List of "Famine Foods."

No.	Local name	English name	Botanical name	District	Remarks
180	Koneri gadde ...	.....	.....	Hassan	
185	Ale soppu ...	.....	.....	Mysore	
186	Navale bhatta ...	.....	.....	Mysore	
209	Hedige genasu ...	Species of yams	Dioscorea ...	Shimoga	
210	Bagani pith ...	.....	Caryota urens ...	,,	
211	Bella genasu ...	.....	.....	,,	
212	Kayi genasu ...	.....	.....	,,	Boiled and eaten.
215	Kumbha genasu ...	.....	.....	,,	
216	Anne soppu ...	.....	.....	Hassan	
219	Mullu genasu ...	.....	.....	Mysore	Boiled and eaten with or without honey.
222	Chesaka seeds ...	.....	.....	,,	Fried, ground and made into gruel said to produce colic.
226	Poondi soppu ...	.....	.....	Hassan.	
228	Bale dhantu ...	Plantain stem...	.....	,,	
230	Akki thowdu ...	Rice ~~tour~~ bran ...	.....	,,	
233	Byaladakayi ...	Wood apple fruit.	.....	Mysore	
235	Bale gadde ...	Plantain root...	.....	,,	

240	Chelle hannu ...	.....	.....	,,	
243	Yeesha soppu ...	.....	.....	,,	
252	Tare kayi ...	.....	Terminalia bellerica.	Kadur	
253	Bangari kayi ...	.....	Randia dumetorum.	,,	The inner fleshy portion cut and boiled with condiments.
254	Chagache soppu ...	.....	Cassia tora ...	,,	
260	Bidaru akki ...	Bambu seed or rice.	Bambusa arundinacea.	,,	Eaten like rice.
265	Myari bhatta ...	.....	.....	Shimoga	
268	Kadu ragi* ...	.....	.....	Chitaldrug	It is stated that ants store 3 to 4 seers of this under ground. People used to go in search of these antholes to collect this grain. It is ground into flour, boiled and eaten.
269	Kathale dhantu* ...	Aloe stem ...	Agave Americana ...	,,	* Eaten during the famine of 1876-77 in Jagalur Taluk.
270	Eachal dhantu* ...	Soft stem of country date.	.....	,,	
271	Jali beeja* ...	Babbool seeds.	Acacia Arabica ...	,,	
273	Thavaray gadde ...	Lotus root ...	Nelumbium speciosum.	Tumkur	
318	Pillagala gadde ...	.....	Typa augustifolia ...	Chitaldurg	The roots eaten raw or boiled. The roots of one plant said to afford food for 2 persons. Used in famine of 1876-77.
323	Agase soppu ...	Agathi leaves...	Sesbania grandiflora.	Tumkur	
349	Tupre hannu ...	.....	Diosperos tupru ...	,,	
375	Navare hannu ...	.....	.....	,,	
387	Amble genasu ...	.....	.....	Bangalore.	

TABLE XV—*concld.*

List of "Famine Foods."

No.	Local name	English name	Botanical name	District	Remarks
383	Thangadi soppu ...	.....	Cassia auriculata ...	Bangalore.	
385	Seege soppu ...	Soap nut leaves.	.....	,,	
386	Hunise soppu ...	Tamarind leaves.	.....	,,	
391	Solle hannu ...	.....	.....	,,	
393	Nagare hannu ...	.....	Ximenia Americana.	,,	
422	Kurdi hannu ...	.....	.....	,,	
423	Burdi hannu ...	.....	.....	,,	

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DEPARTMENT OF AGRICULTURE, MYSORE STATE.

NINTH ANNUAL REPORT

OF THE

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NINTH ANNUAL REPORT OF THE AGRICULTURAL CHEMIST

FOR THE YEAR 1907-08.

PART II.

(Part I comprising paras one to eleven is not intended for general publication.)

Experimental Farm.

DRY AREA.

12. In the appendix on Table No. I and No. II are given the weights of crops realized from all the plots of Ragi which were being tested during the past three years. The yields both of grain and straw are given. As explained in previous reports the object of the present experiment is to standardise the plots. In other words to find out if all the plots, when treated, as far as possible, alike in every detail, will also give the same yield. That is, if one plot gives, say, 150 lbs. of grain and 250 lbs. of straw and chaff, will all the other plots ploughed, manured, sown and cultivated in the same way also give 150 lbs. of grain and 250 lbs. of straw? If so the conditions for making experiments are ideal. Most experimenters have assumed that these ideal conditions generally exist in reality if some care has been taken to select a field which presents a uniform appearance to the eye. They have therefore started their experiments at once without testing the plots with which they intend to make their experiments and have ascribed all the difference in the crop of the various plots to the difference in treatment introduced with the experiment. The frightfully contradictory results obtained by this method of experiment is, in itself, an indication that such experimenters have started with too sanguine expectations.

13. As will be seen from para 35, page 8 of the seventh annual report of this department considerable care was taken in the selection of the Bangalore Experimental Farm. But from the crop returns of the various plots given in the appendix it is evident that the plots are by no means uniform; some plots have given more than twice as much grain and straw as others, not very far away from them, have given during the same season; as for example plot 2, range A and plot 17 of the same range in 1906 or the grain yield in plots 5 and 6, range A in 1905. Under such circumstances it is self-evident that it is absolutely impossible to conduct any experiments of value until the plots have been carefully tested to see how much grain and straw of a certain kind, one plot will give in excess of another plot when treated alike in all respects. If under such conditions the one plot always gives twice as much grain as the other, it is evident that if the poorer plot is treated in a way that will cause it to produce three quarters of the crop produced on the better plot that treatment has actually caused an increase of 50 per cent instead of having produced a loss of 25 per cent as might appear to be the case if these plots had not been tested before. In this way we can make use of plots for experimental purposes even if they are not quite uniform. They are never as serviceable however as plots which are uniform, if such can be found.

14. Plots differing as much as those on the dry area of the Bangalore Experimental Farm, are liable to change their relative productiveness with the season. A wet season may favor one plot and be injurious to another, so that if the relative productiveness of the various plots has been accurately determined for an average season, a different season, for example a wet one, may totally upset this standard and the results obtained during such a season must either be discarded or compared with a standard prepared for such a season. This is strikingly illustrated in the crop returns of Ragi grown for the three seasons as shown in the appendix.

15. Below is given the rainfall for the various months during which the ragi crop was growing in 1906 and the average for the same months during 1905 and 1907 :—

Year	July	August	September	October	Total for the 4 months
1905 and 1907 average	2·53	5·73	3·56	3·28	15·10
1906	7·09	9·98	5·50	8·51	31·08

16. And the following table gives the weight of grain obtained from the second plot in each of the six ranges of the experimental field for 1906 as well as the average yield for the other two years :—

Year	Ranges					
	A	B	C	D	E	F
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1905 and 1907 average	271	191	183	238	247	199
1906 ...	281	88	89	218	205	84
	10	103	94	20	42	115

17. It will be seen that in plot 2 of range A the wet season had a slightly beneficial effect on the crop of grain while on plot 2 on ranges B, C and F it had a very bad effect reducing the crop to less than half. In range D this injurious effect was, comparatively speaking, slight. The ground slopes gradually from range A to range F. And as it is natural to suppose that the lower ground may be affected more seriously by water-logging than that lying at a higher level it is not surprising that the plot in range F should suffer most. But there is absolutely no uniformity in this. The comparatively low lying plots in Ranges D and E have suffered

much less than the comparatively high lying plots in ranges B and C. Throughout the field similar differences can be noticed.

18. The rainfall is not however the only factor beyond our control which could affect the result of the experiment. Differences in the sun's light and heat may possibly cause similar variations in the crop returns. As during rainy weather the sky is clouded and the sunshine is less than it would be when the sky is clear a certain relation exists between the rainfall and the amount of sunshine. But as this relation is very variable, the rainfall is not in itself a sufficient index of the nature of the season under observation. And as the Meteorological Observatory is about 5 miles away it is highly desirable to have, in addition to the rain gauge, other Meteorological instruments on the Experimental Farm.

19. On plots varying as much as those on the Experimental Farm near Bangalore it is a difficult matter to conduct reliable experiments even if the season were practically the same every year. But with variations in the season as great as those of the past three years this task becomes so difficult that it can only be accomplished after a long term of years by a staff having the very highest qualification, and supplied with a good equipment. In view of the present retrenchments in investigation work in Agricultural problems in Mysore it may therefore appear useless to try to continue the work on the Experimental Farm. But as this line of work is of such vital importance to the State, this retrenchment can, I believe, be only of a very temporary nature and as the momentum given to the work may possibly carry it in a mechanical sort of way through this depression it appears to me better to give very detailed instructions of how to carry on the work. For if such instructions are faithfully carried out by the present Farm Manager and the retrenchment does not last too long, the results may possibly be of considerable value when revised and interpreted by a thoroughly qualified man. The safest

thing would be to continue the present testing of the plots. But as *results* are always impatiently looked for and in the hope that the Farm Manager may not be left long without skilled professional guidance I have yielded to the temptation to start two sets of experiments which make use of all the available dry land on the farm.

20. *Standardization of Plots.*—The first thing to be done was to interpret the results of the past three years. As already stated the season of 1906 was an abnormal one when compared with 1905 and 1907. During the growing season of ragi, the rainfall was more than twice as much as the average of the other two years. The crop returns from many of the plots were quite abnormal when compared with the other years. The results obtained during that year must therefore be discarded when preparing a standard for years like 1905 and 1907. But for years as wet as 1906, that year's crop would of course form a much better standard for comparison than the standard set by the average of the years 1905 and 1907. But the years 1905 and 1907 had a rainfall considerably below the average of the past ten years, as will be seen from the following table:—

Month	Rainfall			
	1905	1906	1907	Average of 10 years
July ...	1·77	7·09	4·17	3·04
August ...	6·75	9·98	1·50	4·32
September ...	1·47	5·50	5·66	8·14
October ...	5·76	8·51	0·81	5·97
Total ...	15·75	31·08	12·14	21·47

In the year 1905, the rainfall was below the average in July and again in September. In August it was considerably above the average. But notwithstanding this the grain suffered most for want of rain in August, for all the rain fell in the second half of the month (the

first half was without rain) and as the soil was already rather dry at the beginning of this dry spell the crop must have suffered more during August than in July, notwithstanding that the latter part of the month was very wet. But as the plants were very young and required but little moisture and the surface soil was loose and protected the moisture in the soil from evaporation, the injury was probably very much less than it would have been if such a dry spell had occurred later in the season when the crop would have been larger and required more water and the soil more compact and would have lost more water by evaporation. This indicates the necessity of studying the rainfall as well as the condition of the crop and soil instead of simply looking at the monthly rainfall when trying to interpret the results of plot experiments. When studying the daily rainfall for the seasons 1905 and 1907, the fact that their total rainfall has dropped below the average does not appear to have damaged the crop much more than might be expected during an average season. And if sufficient caution is exercised in the interpretation of the results, the averages of these two seasons may, I think, be taken as a standard for judging average seasons. As already stated, the year 1906 was very wet. This is even more strikingly illustrated when comparing the *number* of rainy days during the season with the average, as given below, than by comparing the *total rainfall*:—

	July	August	September	October	Total
1906	15	22	18	17	72
Average of 10 years	6·7	9·3	12·7	8·9	37·6

The total rainfall is only a little over 44 per cent above the average, while the rainy days are the highest for any of the 10 years (the next highest being 41). This is a little over 91 per cent above the average of the past 10 years. The total sunshine has therefore probably been relatively speaking very little and the soil has been

much more saturated with water. For as nearly 60 per cent of the total number of days were rainy the soil had no chance to dry on the surface as it could in other years when an average of only a little over 30 per cent were rainy days during that season of the year. A year like 1906 is not likely to be met with again very soon. This together with the varying crop returns justifies me, I think, in disregarding the results obtained during that year for the present when we are trying to get a standard for the various plots for an average season.

21. The average crop for all the ragi plots in 1905 was 180·43 lbs. of grain and in 1907, 160·43 lbs. of grain. In order to make the results of the two years more easily comparable both these average crops were put down at 100 and the yield of all the other plots was calculated to percentages of the average. This enables us to see at a glance the relative productiveness of the plots, about which I shall speak later, as well as the variations of each plot from year to year. In the Appendix these percentages are given in tables No. III and IV for the three years the work has been in progress. In these tables the great variations in the crop of 1906, already referred to, can be readily seen. Even for the years 1905 and 1907 the variations in some of the plots is very great, running up to 69 per cent in the case of the crop of grain on plot E 17 and to 75 per cent in the total crop on plot F 11. Why such variations should occur in two comparatively similar seasons may be difficult to explain. But that where such differences exist the plots are absolutely useless for experimental work is self-evident. For example, a plot like E 2 which varied in the two seasons less than 5 per cent. of the average crop is likely to continue giving fairly uniform crops while the treatment it receives remains the same. Under normal conditions we may therefore conclude that if a change in cultivation produces repeatedly a change in crop of more than 10 per cent. and always in the same direction that this change in crop is largely due to the change in cultivation. But if a plot varied in its annual crop returns (reduced to percentages of the average of each

year) by, say, 20 per cent when treated the same, a variation of 20 per cent produced by a difference of treatment might remain unnoticed for a long time on such a plot. In order to get conclusive results in a comparatively short time, it is therefore essential that the plots used for the experiments should give practically constant results when treated alike. The more variation there is in the plots under uniform treatment, the less conclusive the results of the experiments become, the longer the time required to get these results and the more limited the scope of the experiments it is possible to undertake. If possible I should therefore have excluded all plots showing a variation of more than 10 per cent. But as this would have reduced the number of available plots too much I have retained all showing a variation of less than 20 per cent in both total crop and crop of grain and have also retained 3 which showed a slightly greater variation than this.

22. Out of the total of 105 plots tested, 45 were discarded. Of the remaining 60 plots over two-thirds showed variations of less than 10 per cent in the yield of crop for the two seasons. The average variation was 7·82 per cent and only one-eighth of the number showed variations over 15 per cent when considering both the total crop and yield of grain separately.

23. In addition to the variations in crop produced by the same plots in different seasons referred to above there was also a difference in the relative productiveness of the plots which remained more or less constant during the seasons. In fact the object for sowing the test crop was chiefly to determine this comparatively constant difference in the productiveness of the plots. For example, plot E 2 which varied less than 5 per cent in the constancy of its grain crop gave about 43 per cent above the average crop. Plot C 18 gave almost as constant results, but produced only about 59 per cent of an average crop. Evidently the results of experiments made on these two plots though valuable in themselves cannot be compared with each other until the relative

productiveness of these plots is determined, and the actual results which have been obtained are corrected to allow for this original difference in productiveness. This has already been referred to on para 13 of this report, but perhaps I may repeat. If for instance plots E 2 and C 18 had been treated alike, except that C 18 had been manured with 6 lbs. of sulphate of potash, and plot E 2 had given 43 per cent above the average yield and plot C 18 only 1 per cent above the average for that year it would appear as if the application of the 6 lbs. of sulphate of potash had reduced the crop by 42 per cent of the average unless we knew that there was a considerable difference in the productiveness of the two plots to start with. But knowing the original relative productiveness of these two plots we should find that instead of having caused a decrease of 42 per cent of the average there had been an increase of that amount on the plot which had received the application of the potash fertilizer.

24. In this way, we are able to compare the results of plots even if they are not uniform provided they are constant in their crop returns under uniform treatment.

25. Table No. V in the appendix gives the relative productiveness of the various plots retained for experimental purposes. This relative productiveness is calculated from the crops produced during the two years 1905 and 1907, and naturally applies only to years having a season somewhat similar to these. Great care must therefore be exercised in using it. It would, of course, be very much better to have plots of uniform productiveness to begin with. But as these have not been found it is undoubtedly necessary to use a factor for correcting such mistakes, and this factor is given in the table referred to above.

26. The objection may be raised that possibly other mistakes, which I have not allowed for, may exist in a set of field experiments conducted on such land as that we are experimenting with. Very possibly they do exist. But the fact that the field has been tested and that com-

paratively uniform crops have been obtained on the plots selected indicates that these other mistakes are not likely to be very serious. Besides, all experiments will be made in duplicate and the variations in relative productiveness of the plots will be toned down by selecting the duplicate plots in such a way that both together will be approximately equivalent to two average plots. For example, in green-manuring experiments plots E 2 and F 22, the one giving crops about 43 per cent above, and the other about 48 per cent below the average are selected for duplicates. Again, plots C 7 and C 8 are duplicates both giving within 4 per cent of an average crop. The average of the two duplicate plots ought therefore in itself to give an indication of the result of the experiments and if serious objections should be taken to use the factors given in Table VI, it is not necessary to do so in future except to see in how far the duplicate plots give concordant results. That is however in itself a very important matter. For if the duplicate plots do not give concordant results the experiments are undoubtedly unreliable. Besides it was absolutely necessary to have these factors in order to arrange the duplicate plots in a way to make both of them together approximately equivalent to two average plots.

27. *Experiments proper.*—One of the first subjects which naturally presents itself as requiring investigation when considering the cultivation of ragi, is that of the time for sowing the crop. In different parts of the State the time of sowing ragi differs greatly. This is no doubt partly due to the difference in climate in various parts of the State. But even in parts of the State where the climate is similar great differences in time of sowing are found. In the neighbourhood of Bangalore, the usual time for sowing is early in July. In Mysore it is sown very much earlier, and judging by the rainfall there appears to be no reason why it might not be sown earlier here. In other countries it has been found that the time of sowing has frequently a great effect on the outturn of the crop and in order to test in how far the time of sowing affects the ragi crop in the neighbourhood of

Bangalore, 18 plots have been set aside for this purpose. The time when these plots are to be sown is as follows:—

Plots	Productiveness of plot compared with average of the whole field		Average	Time of sowing
B 3 & B 17 ...	119	71	95	In April immediately after the second good shower of rain, both together having given 1 inch or more of rain.
B 9 & A 19 ...	113	78	95	In May after the first shower of 40 cents.
B 8 & B 18 ...	112	79	95	June 1st.
B 6 & B 19 ...	111	80	95	June 10th.
B 10 & B 20 ...	110	91	100	June 20th.
B 2 & A 10 ...	110	91	100	July 1st.
B 11 & B 14 ...	106	96	101	July 10th.
B 12 & B 13 ...	104	98	101	July 20th.
A 8 & A 11 ...	104	100	102	August 1st.

28. Intimately connected with this series is the second, that of green manuring. One of the difficulties in the way of introducing reaping machines for harvesting ragi is that a leguminous crop which ripens some time after the ragi is generally sown with the ragi. As a rule these legumes are sown in rows dividing the ragi field into a large number of narrow strips which it would be impracticable to cut with a reaping machine. In a country in which the soils are so poor in nitrogen as in Mysore a rotation with a leguminous crop is undoubtedly very desirable. It would be difficult, however, to induce the raiyats to grow only ragi in a field one year and follow that with a legume the next year. But if he can grow a legume and ragi following each other in the same year there is some chance of inducing him to do that if by so doing he can use a reaping machine. And when studying the rainfall record for the past ten years there are apparently two months either before the ragi is sown or after it has been cut, which may be devoted to the growing of a leguminous crop. This leguminous crop I propose to plough into the soil thus adding organic matter as well as nitrogen to the soil.

29. Most of the maidan Mysore soils are very deficient in organic matter and are very subject to crust formation. Adding organic matter to them will undoubtedly improve their mechanical condition and will probably enable them to withstand short periods of drought very much better. But judging from the pot-culture experiments an addition of organic matter to the soil appears to have a slight tendency to act injuriously on the growth of ragi. But further experiments are required to test this point and, if confirmed, to determine the reasons for this action. And I only mention the matter now to indicate that we are not justified in assuming that the application of a green manure, must, as a matter of course, act beneficially. Experiments are required for the purpose of finding out (*a*) if the growing of a green manure is desirable, and if so (*b*) what crop gives the best green manure for ragi, (*c*) when can this crop be grown to best advantage and (*d*) is any other manuring necessary and if so, what kind of fertilizer is likely to be required.

30. To try to answer the above problems the following set of experiments has been started. And as it could be easily done a further experiment has been added which it is hoped will give some indication as to the effect of allowing the land to lie uncultivated for nearly six months (as is now generally done) after the crop has been removed until shortly before resowing the land :—

Number of plots	Relative productiveness in grain (per cent of average crop)			Treatment of plot
	Of individual plots		Average of duplicate plots	
D 4 and F 13 ...	126	74	100	Ploughed as soon as the ragi crop is harvested and kept cultivated to prevent a crust from forming or weeds from growing till resown with ragi after the first shower of 40 cents in May.
F 7 and C 20 ...	125	74	100	Sown with ragi after the first shower of 40 cents in May. Ploughed as soon as the ragi has been harvested and sown with *black gram*. The black gram to be ploughed in 7 weeks after germinating.
F 4 and E 19 ...	119	76	97	As above but sown with *green gram* instead of black gram.
F 2 and F 15 ...	115	80	97	As above but sown with *sunn hemp* instead of green gram.
F 1 and C 15 ...	109	83	96	As above but sown with *cow peas* instead of sunn hemp.
E 7 and F 21 ...	107	84	95	As above but sown with *avare* instead of cow peas.
D 6 and C 14 ...	107	85	96	Plots sown with ragi and avare after the first shower of rain of 40 cents in May. Avare to be ploughed in next year shortly before the plot is again sown with ragi and avare next May.

Number of plots	Relative productiveness in grain (per cent of average crop)			Treatment of plot
	Of individual plots		Average of duplicate plots	
F 17 and C 13 ...	105	87	96	Plots sown with ragi in July on the same day as the following plots (F 20 and C 11). After reaping the ragi the plots to be left untouched until just before sowing ragi next year. The stubble to be ploughed in on the same day the black gram is being ploughed in on plots F 20 and C 11.
F 20 and C 11 ...	105	88	96	Plots sown with *black gram* after the first shower of 40 cents in May. This ploughed in seven weeks after it has germinated; (but not later than July 20) and sown immediately (within two days after ploughing) with ragi. The plots to be again ploughed up immediately after the ragi has been harvested and again sown with black gram next May.
C 5 and F 18 ...	103	90	96	Same as above but sown with *green gram* instead of black gram.
D 5 and C 6 ...	101	93	96	Same as above but sown with *sunn hemp* instead of green gram.
C 10 and C 12 ...	101	93	96	Same as above but sown with *avare* instead of sunn hemp.

F 19 and D 8 ...	100	94	97	Plots sown with ragi on the same day as plots C 10 and C 12; ploughed immediately after the crop of ragi has been removed; kept stirred to prevent a crust from forming or weeds from growing until it is again sown with ragi in July of next year.
C 8 and C 7 ...	96	97	96	Plots sown with ragi and avare after the first shower of 40 cents in May. Avare to be ploughed in immediately after the crop of ragi has been removed and the soil kept stirred to prevent a crust from forming or weeds from growing till again sown with ragi and avare next May.
E 2 and F 22 ...	143	52	97	Plots manured with *6 lbs. of sulphate of potash* (30 lbs. of K_2O per acre). Ragi sown after the first shower of 40 cents in May. Plots ploughed as soon as possible after ragi has been cut and sown with *black gram*. The black gram ploughed in seven weeks after it has germinated.
E 3 and C 18 ...	143	59	101	Plots manured *with 15 lbs. basic slag* (30 lbs. of phosphoric acid per acre), otherwise treated as above.
E 5 and A 17 ...	135	59	97	Plots manured with *6 lbs. of sulphate of potash and 15 lbs.* of basic slag (30 lbs. of potash and 30 lbs. of phosphoric acid per acre). Otherwise treated as above.
F 6 and A 18 ...	131	62	96	Plots manured with 6 lbs. of sulphate of potash. 15 lbs. of basic slag and 23 lbs. of white castor ($6\frac{1}{2}$ per cent nitrogen) or its equivalent in other forms of oilcakes. (30 lbs. of potash, 30 lbs. of phosphoric acid and 15 lbs. of nitrogen per acre), Otherwise treated as above.

Number of plots	Relative productiveness in grain (per cent of average crop)			Treatment of plot
	Of individual plots		Average of duplicate plots	
E 6 and D 18 ...	131	62	96	Plots manured with 6 lbs. of sulphate of potash and 15 lbs. of basic slag (30 lbs. potash and 30 lbs. of phosphoric acid) and sown with black gram after the first shower of 40 cents of rain. The black gram to be ploughed in seven weeks after it has germinated (not later however than July 20th) and immediately sown with ragi. As soon after the ragi crop has been cut as possible the plots to be again ploughed up and kept stirred till resown with black gram next season.
F 5 and F 14 ...	129	71	100	Manured with 23 lbs. of white castor (6½ per cent. nitrogen) or its equivalent in other forms of oil-cake, (15 lbs. of nitrogen per acre). Otherwise treated as plots E 6 and D 18 above.

31. As will be seen from the above table the extreme variations in the relative productiveness of the average of the two duplicate plots is only 5 per cent, provided the two years' results are sufficient to indicate the actual relative productiveness of the various plots in question.

32. The object of using a green manure is, as already stated, to provide the soil with organic matter and to act as a nitrogenous manure. In the maidan soils of Mysore nitrogen is, as a rule, very deficient and anything which supplies them with this constituent of plant food in a cheap form is likely to be a great blessing. Even if the organic matter does not directly help in the growth of the plants it improves the mechanical condition of the soil and helps them to retain, all the more readily, moisture which is so essential to plant growth. It is also likely to lessen the tendency to crust formation from which the Mysore soils suffer so much. To be able to plough in a crop of green manure is therefore likely to be a very important factor in a rational system of agriculture for Mysore.

33. A leguminous crop may under certain circumstances draw the supply of nitrogen required for its growth indirectly from the atmosphere. By ploughing in such a crop the amount of nitrogen in the soil may be increased. But as these plants depend on the regular store of plant food in the soil for the potash, phosphoric acid and lime required to build up their tissues the ploughing in of such a green crop cannot add to the quantity of these constituents of plant food. Therefore if a soil is lacking in these constituents a green manure will not remedy that defect. In fact if such deficiencies are very marked it will be impossible to grow a good crop for green manuring without supplying these deficiencies. In order to find out what constituents of plant food other than nitrogen were required to produce good crops, some potash and phosphoric acid fertilizers are to be applied to some of the plots on which the green crops are to be grown and in case the green crop should be unable to supply all the nitrogen required by

the ragi, or some of the conditions required to enable the legumes to draw effectively on the store of atmospheric nitrogen should be wanting, a small application of nitrogen will also be given to some of the plots.

34. In order to determine which of the legumes generally grown in India are best suited for green manuring ragi the following have been selected to begin with for experiments :—

Ordinary name	Botanical name
Black gram.	Phaseolus mungo ; var : radiatus.
Green gram.	Phaseolus mungo.
Cow gram	Vigna catiang.
Sunn hemp	Crotolaria juncea.
Avare	Dolichos lablab.

35. Togari or pigeon pea (Cajanus indicus) was discarded for the present on account of its large woody branching stem. Somethings desired in the plant sought for are that they should be able to make considerable growth either early in the season before the ragi is sown or late in the season after the ragi has been cut so that their growth does not interfere with that of the ragi ; and that they contain a large supply of nitrogen and decompose sufficiently fast to enable the succeeding crop of ragi to get the benefit of the plant food stored in their tissues.

36. But it is unnecessary to enter more fully into the problems on which it is hoped that this series of experiments will give some light if properly carried out.

37. Lack of space prevents undertaking any other experiments with ragi at present. There are however a large number of equally important subjects which require solution, as for example :—(*a*) The effect of deep and shallow cultivation on ragi. (*b*) The effect of sowing only large plump grains compared with sowing small and malformed grains. The advantages of a careful seed selection have been found to be very great in temperate

climates and there appear to be no reason why they should not be equally great here. (*c*) Manurial experiments in which cattle manure which is now almost exclusively used is compared with such commercial fertilizers as oilcakes and in which an attempt is made to find out what constituents of plant food ragi requires most urgently. (*d*) Rotation experiments should also find a place on the Experimental Farm if possible. And (*e*) experiments with the different varieties of ragi should also be conducted as soon as time and space permit. But as none of these can be undertaken in the near future it is useless to make plans regarding them.

PADDY.

38. Five crops of paddy have been grown on the experimental area. Of these one produced no grain as reported on pages 21 and 22 of the 8th Annual Report. What the cause for this non-production of grain was, has not yet been determined. Another suggestion in addition to those made in the report mentioned above for the non-production of the grain is that the season was too cold for the fertilization. This appears to be the most likely suggestion made up to the present. The crop returns are given in Tables No. VI and No. VII in the appendix.

39. The variations of the remaining four crops are much greater than in the dry area. This is what might have been expected as on the one hand each additional year gives opportunities for greater variation without reducing the variation already recorded. And secondly as any irregularities in irrigation are likely to produce differences in the crop it is more difficult to make the factors influencing the growth uniform. Out of the 34 plots the ten showing the greatest variations in productiveness have been discarded and of the remaining 24, 6 have been reserved for studying problems with irrigation. This number is, I admit, much too small to do justice to that very important subject. But as special measuring tanks and other appliances will have to be put down before these experiments can be begun and as possibly

some of the other experiments may be abandoned by that time it did not appear wise to leave more plots unused at present.

40. The following is the plan of the experiments outlined at present :—

PLAN OF EXPERIMENTS WITH PADDY.

Number of plots	Relative productiveness in grain (per cent of average crop)		Treatment of plot
	Of individual plots	Average of duplicate plots	
B 1 and C 17 ...	132	100	Ploughed dry, 4 inches deep, transplanted.
	68		
B 6 and B 17 ...	115	95	Ploughed dry and sown broad-cast.
	76		
B 5 and C 16 ...	115	97	Ploughed dry and seed drilled in on well harrowed dry soil in drills made about 2 inches deep and sown with sprouted paddy at the rate of about 16 lbs. per plot. Water let on immediately after sowing.
	80		
B 8 and B 12 ...	96	88	Ploughed just before sowing in puddle; transplanted.
	80		
B 14 and C 15 ...	93	88	Ploughed dry, 8 inches deep, transplanted.
	82		
B 10 and C 13 ...	92	87	Green manuring with sunn hemp (no other manure).
	82		
C 11 and B 16 ...	90	87	Rotation with chenna (no manure).
	84		
B 15 and C 12 ...	89	88	Manured with saltpetre.
	88		
B 9 and B 13	88	88	Manured with basic slag and sulphate of potash and saltpetre.
	88		

41. As will be seen, the experiments are compressed into a very small area. The manurial experiments have been undertaken because some old experiments conducted in Burma appeared to indicate that paddy required particularly phosphatic fertilizers. Some more recent experiments in India are said to show that paddy responds to a surprising extent to saltpetre. These differences are probably due partially to experimental errors and partially to the differences in the requirements of the soil. The other experiments need, I believe, no special comment except perhaps the reason for including the experiment to plough the plot 8 inches deep instead of 4 inches. This is on account of my having noticed very marked differences in the growth of paddy where it had been dug deep as compared with ordinary cultivation.

PHOSPHATES IN FOODS.

42. At the Mysore Dasara Exhibition a young and self-appointed exponent of the relative value of ragi and rice was heard to say in defence of rice "Although ragi may contain the same quantity of food material as rice it does not contain the phosphates which are a brain food. Eating ragi dulls the brain." As further questioning showed that this young man really expressed a popular idea in Mysore about ragi it was decided to determine the percentage of phosphoric acid in rice and ragi and also in the "brain food" oat meal. The result was that rice contained 0·35 per cent phosphoric acid, ragi, 0·69 per cent and oat meal, 1·02 per cent. If therefore the fact that a food contains a high percentage of phosphoric acid were an index of its value as a "brain food" ragi would be worth nearly twice as much as rice as a "brain food." But unfortunately for ragi its relatively high phosphoric acid content when compared with rice is no infallible sign that it is a "brain food;" for the popular belief that a high phosphoric acid content makes a food a "brain food" originated, if I am not mistaken, in a joke. But it certainly indicates that it does not "dull the brain because it is deficient in phosphoric acid."

43. The fact that ragi is so extensively used in Mysore and that the quotation given above is so generally accepted as true justifies me in specially referring to this matter.

QUALITY OF COFFEE.

44. As mentioned on page 17 of the 5th Annual Report of this Department 51 samples of coffee were received through the Secretary of the United Planters' Association of Southern India to determine if any chemical or physical test would give a sufficient index of their quality (as indicated by their market price) to be of value in determining the relative quality of a series of samples grown on the same experimental field. If such a test could be found it would be of very great value when carrying on cultivation experiments regarding the quality of coffee. Questions are often asked as to the effect of certain manures or of certain methods of cultivation on the quality of coffee. In order to be able to answer these questions a large number of very carefully conducted experiments will have to be made. But until we have a method for testing the quality of coffee which permits us to express that quality in numerical form and in a way that enables us to compare one year's results with those of another year, it will be very difficult, if not impossible, to carry on these experiments.

45. That the quality of coffee depends upon its composition must be taken for granted. If sufficient skill and time could be devoted to the subject it must therefore be possible to determine the quality of coffee by chemical methods. But up to the present these methods have not, I believe, been discovered and there appear to be no indications that they are likely to be discovered in the near future.

46. However my attempts have not been to discover the constituents of coffee which give it its quality and to determine these, but simply to find out some easy method which would give us a sufficiently reliable indication of the quality. If the application of manures has

an effect on the crop of coffee a part of the manure must be taken up by the coffee tree, some of the elements taken up by the tree from the soil are stored in a different combination in the coffee beans themselves. If manuring had any marked effect on the quality of coffee it is not unreasonable to suppose that possibly this effect might be expressed by there being a larger or smaller per cent of some one or other of the constituents of plant food in the bean and further that the quality of the coffee might possibly vary in direct or inverse proportion to the quantity of some one or other of these constituents found in the bean. The determination of the quantity of nitrogen and the ash constituents of the coffee bean were largely undertaken with a view to getting some light on this point.

47. In addition to these analyses it was the intention to determine the ether extract, crude fibre, caffein, tannic acid and, if possible, some of the other constituents of the coffee beans. But of these only the crude fibre and the ether extract have been completed. Lack of time forbade the determination of the other and probably more important constituents.

48. In Tables No. VIII to No. XVI in the appendix the samples of coffees from the various districts have been grouped together in the order of their quality as indicated by the price they brought on the London market. If the percentages of nitrogen found in the 13 samples of Mysore coffee which have been analysed are studied it might appear that in a general way the percentage of nitrogen increased with a decrease in quality. Some of the other districts show a similar tendency. But this increase is not sufficiently regular to deserve consideration and in the Costa Rica coffees there is, if anything, a slight tendency in the opposite direction. The same irregularity with a slight tendency to increase with decreasing quality may be noticed in the other constituents of plant food. None of them are therefore, as far as can be seen at present, of much value in determining the quality of coffee. The crude fibre gives

apparently no indication at all and the ether extract is about as irregular as the other constituents but apparently has a tendency to decrease with decreasing quality.

49. The specific gravity of the bean is, however, as pointed out on page 23 of the 5th Annual Report, a fairly reliable index of quality and certainly continues to remain the best numerical index we have at present of the quality of coffee.

SUGAR-CANE.

50. During the year the Hebbal tank which supplies the water for the wet area of the Experimental Farm was dry for several months. An attempt to supply the necessary water for the sugar-cane area was made by digging a well just below the tank on Plot A 1. But the supply of water from this well was found insufficient to keep the sugar-cane in normal growth. The crop was very much stunted. Besides a considerable amount of disease made its appearance probably as a result of the defective nutrition due to the lack of water. The cane was cut in an immature and diseased condition. Some good sugar was made notwithstanding this and sold at Rs. 2-8-0 per maund of 28 lbs., a very satisfactory price as it was the same as that for which refined sugar was sold at the time. But on account of the want of water this year's work was a failure as far as the sugar-cane experiments are concerned and although everything has been weighed and analysed it serves no useful purpose to publish these results.

51. All the plots were planted partially with whole canes, partially with cane tops which had been lying in a heap for about two months and partly with freshly cut tops. The whole cane germinated very badly and in the old tops there was a considerable failure in germination. A month after planting all the vacancies were filled in by planting fresh tops and these germinated well but the difference due to planting one month later could be seen throughout the season. The difference of the crop in favour of planting freshly cut tops

was 26 per cent. when compared with the whole cane and 3 per cent. when compared with the rows in which tops had been planted which had been cut two months before planting. As the crop did not ripen properly these differences are probably more marked than they would otherwise have been. They indicate however that planting whole cane is not necessarily advantageous under all circumstances.

52. Mr. Nuir Ahmed Khan, one of the sugar boilers working under the direction of Mr. S. M. Hadi, Assistant Director of Agriculture in the United Provinces, was sent here by the Department of Agriculture of the United Provinces to learn the system of sugar making used on the Experimental Farm here. The object was to introduce liming of the juice to neutrality into the United Provinces if by so doing they can make a sufficiently colourless sugar for the demands of their home market.

53. As in the Godavary valley the prevalence of sugar-cane disease is supposed to be due to want of proper drainage, the fact that this year we found it prevalent when there was a lack of water, appears to indicate that unfavourable conditions of growth in general predispose the sugar-cane to disease.

54. One of the most important things to study about sugar-cane growing when considering the development of the industry in Mysore is the length of the sugar-cane season. The longer the season during which cane can be planted to advantage the more extended the harvesting season will naturally be and the longer the harvesting season and the longer the sugar machinery can be kept at work the more economical it will be. But when extending the manufacturing season we must watch that by so doing we are not sustaining a loss on the agricultural side by getting smaller crops due to planting the cane either too early or too late.

55. Eight plots have been selected to study the effect which the time of planting has on the crop produced. One of these plots was planted on August 11th

and every 52 days another plot will be planted. The eighth plot of the series will be planted on August 11th of next year and the plot planted last August will have to be replanted with cane on October 2nd of next year. This will enable us to let the cane on the first plot grow 13 months if necessary and still have ample time to replant it in time to form the second plot in the series next year. The following year it will become the third plot until in the seventh year after the experiment has been begun it will be the last plot in the series. A complete circle of experiments will therefore have been finished on this plot in the course of eight years and in nine years after the experiment has been begun each of the eight plots will have had sugar-cane planted on it on interval of a little over seven weeks throughout the year. The following table will explain this perhaps more clearly :—

Plot No.	Date of planting			
	1908	1909	1910	1911
8	Aug. 11	Oct. 2	Nov. 23	
7	Oct. 2	Nov. 23		Jan. 14
6	Nov. 23		Jan. 14	Mar. 7
5		Jan. 14	Mar. 7	Apr. 28
4		Mar. 7	April 28	June 19
3		April 28	June 19	Aug. 11
2		June 19	Aug. 11	Oct. 2
9		Aug. 11	Oct. 2	Nov. 23

Plot No.	Date of planting				
	1912	1913	1914	1915	1916
8	Jan. 14	Mar. 7	April 28	June 19	
7	Mar. 7	Apr. 28	June 19	Aug. 11	
6	Apr. 28	June 19	Aug. 11	Oct. 2	
5	June 19	Aug. 11	Oct. 2	Nov. 23	
4	Aug. 11	Oct. 2	Nov. 23		Jan. 14
3	Oct. 2	Nov. 23		Jan. 14	Mar. 7
2	Nov. 23		Jan. 14	Mar. 7	Apr. 28
9		Jan. 14	Mar. 7	April 28	June 19

56. One of the advantages in this arrangement is that after the experiment is completed the variations which exist in the plots are made comparatively harmless because each plot forms, in a way, a record in itself and the results of the eight years' work ought to give a very decided answer to the question "during what months of the year may the variety of sugar-cane experimented with be planted with reasonable prospects of success." It is taken for granted, of course, that all the plots will be treated uniformly throughout the period of experiment and that the manuring and the other cultivation is such that the plots will continue to produce a normal crop of sugar-cane.

57. As the past years' results of the sugar-cane experimental plots cannot be used for standardising these plots any standard which might be made would have to be based on single year's result. For the first eight plots this standard is fortunately not necessary. For the other eight plots I propose a set of rotation experiments. Paddy and sugar-cane to be grown alternately on four of the plots; two with paddy and two with sugar-cane each year. On the other four plots sugar-cane is to be rotated with a leguminous crop. Owing to the small number of plots at our disposal and the desirability of trying at least two leguminous crops for rotation with sugar-cane only one plot can be used for each of the two leguminous crops selected, namely, chenna and ground-nut. These legumes will be grown alternately with sugar-cane. Fortunately four out of the eight plots to be used for this work gave almost the same weight of sugar-cane last year. And with the exception of plot 14 the plots available for this work appear to be fairly uniform. This together with the fact that four plots are devoted to each experiment compensates in a measure for the unfortunate fact that the plots have for practical purposes only been tested for one year.

POT CULTURE.

58. During the year thirty-six pot culture experiments were conducted in duplicate with ragi (Eleusine coracana) and on most of the pots avare (Dolichos lablab) was grown after the ragi had been harvested. The objects of the experiments were to test the availability of bone meal under varying conditions and the effect of various other fertilizers on ragi. Part of this work was begun last year and the objects for undertaking this work are given in para 84 of last year's report. As stated there, some ground bones which had been sown on top of a mulch of leaves on a Coorg coffee estate decomposed completely in less than one year's time. On that estate the leaves falling from the shade trees and from the coffee soon covered the bone meal and all of these gradually changed into a layer of vegetable mould in which the bone was imbedded. On another coffee estate ground bones which had been applied in pits were still dug up 29 years or more afterwards in a fairly sound condition. On the one estate the ground bones were no doubt a readily available manure while on the other estate they were practically useless.

59. The object of one part of this experiment was to find out the conditions which made ground bone a readily available fertilizer. As the organic matter used in these experiments last year had decomposed very little, if any, it was decided to make our own leaf mould. This was made by collecting dried leaves, grinding them to a coarse powder and keeping them moist in a tin can till transformed to a mould.

60. The bone meal was taken from a commercial sample. All finer than 2 mm (one-twelfth inch) in diameter was sifted out and of the part remaining on the sieve all that which did not pass through a 5 mm (one-fifth inch) mesh was taken out. The bone meal used varied therefore from about one-twelfth to one-fifth inch in diameter. All the soil used for the experiments had been passed through a sieve having a 1 mm

(one twenty-fifth inch) mesh. This was done to enable us to easily separate out all the bone meal applied to the soil which had not decomposed during the experiments, and as we had not a soil at our disposal which was sure to respond sufficiently to an application of phosphatic manures, it was necessary to have this mechanical way of testing the result of the experiment. For unless the soil used for the experiment was very deficient in phosphoric acid the growth of the plant would not be a reliable index of the amount of bone meal decomposed.

61. Twelve and a half grams (nearly half an ounce or a little over one tola) of bone meal were applied in various ways to the pots. In some it was mixed with the top two inches of soil, being either left in that condition or covered with leaf mould or the leaf mould was mixed with the soil and the bone meal. In another set the bone meal was applied on the top of the soil and covered with six ounces of leaf mould or placed on top of a layer of leaf mould and covered with cut leaves. The leaves were kept from being blown away by a piece of wire netting tied over the pots. In a third set of experiments an equal quantity of lime was applied with the bone meal. In all the experiments sulphate of potash equivalent to 75 lbs. of potash per acre were used. The following table gives the results of these experiments:—

Decomposition of bone meal.

Experiment	Pots	Treatment	Weight of boue applied	Bone recovered		Per cent decomposed
				Coarse over 2 mm	Fine between 1 and 2 mm	
			Gr.	Gr.	Gr.	Gr.
1	59 and 71	Coarse bone meal applied on top of soil, covered with six ounces of leaf mould.	12·5	10·2	1·00	10·4
2	61 „ 73	Coarse bone meal applied on top of a layer of leaf mould covered with cut leaves.	12·5	10·3	1·20	8·0
3	52 „ 64	Coarse bone meal mixed with top two inches of soil, uncovered.	12·5	8·3	1·27	23·4
4	60 „ 72	Coarse bone meal mixed with top two inches of soil and covered with six ounces of leaf mould.	12·5	8·29	1·43	23·0
5	54 „ 66	Coarse bone meal and six ounces of leaf mould mixed with top two inches of soil, uncovered.	12·5	9·7	·88	15·4
6	55 „ 67	Coarse bone meal and 12½ grams of lime mixed with the top two inches of soil, uncovered.	12·5	8·5	1·1	23·2
7	56 „ 68	Coarse bone meal, 12½ grams of lime and six ounces of leaf mould mixed with the top two inches of soil, uncovered.	12·5	9·0	1·08	19·8

62. A widely accepted theory regarding the decomposition of bone meal in the soil is that carbonic acid plays an important part in this decomposition. Based upon this theory is another. This is:—As carbonic acid is one of the chief factors in dissolving bone meal and as lime also requires carbonic acid to dissolve it when in the form of a carbonate it is a bad practice to apply lime and bone meal together as the lime by taking away the carbonic acid retards the decomposition of the bone meal.

63. To a number of pots leaf mould was applied in the hope of supplying an abundance of carbonic acid, for the decomposing leaf mould and the water supplied to the pots daily would yield the carbonic acid. If the above theories were correct those pots in which lime had been applied without leaf mould should be those in which the bone meal had decomposed least, and in those to which leaf mould had been applied without lime the bone meal should have disintegrated most rapidly. In reality the results of the experiments are almost the exact reverse of this. The application of leaf mould has retarded the decomposition of the bone meal very decidedly. This will be seen by comparing experiments Nos. 3 and 5. In these experiments the application of leaf mould has reduced the decomposition of the bone meal by 8 per cent of the total bone applied or by over 34 per cent of the amount decomposed in experiment No. 3. The application of lime by itself has had very little, if any, effect as may be seen by comparing experiments Nos. 3 and 6. But when applied with leaf mould it has apparently overcome some of the injurious results of the latter as is indicated by the results of experiments Nos. 5 and 7. Leaving the bone meal on the surface of the soil either covered by a layer of leaf mould or between a layer of leaf mould and leaves has retarded the decomposition very considerably as may be judged by comparing experiments Nos. 1 and 2 with experiments No. 3 or No. 4. When remembering that on the one estate on which the bone meal decomposed so quickly it was applied practically as in experiment No. 2 these results are very surprising. Evidently this rapid decom-

position of the bone meal on the estate in question was due to other causes than that of it being applied practically between a layer of leaf mould and leaves. Possibly this great difference in results may be due to the micro-organisms having caused the decomposition of the leaves on the estate and in the laboratory compound having been different. In the experiments under review even covering the soil with leaf mould appears to have had, if anything, an injurious effect as may be seen when comparing experiments Nos. 3 and 4. This particular sample of leaf mould had therefore an injurious effect on the decomposition of the bone meal no matter how applied and as it is difficult to understand how leaf mould, as such, could exercise a preserving influence on the bone meal this effect was probably due to the leaf mould having interfered with the development of some of the micro-organisms in the soil.

FARM MACHINERY.

64. Of the machinery imported this year the "Pennsylvania Thrasher," manufactured by Messrs. Heebner & Sons, Lansdale, Pennsylvania, has undoubtedly attracted most attention. A large number of applications were received from raiyats in various parts of Bangalore District to thrash their ragi with this machine. Some of these requests were complied with and as the work turned out appeared to be very satisfactory to the raiyats concerned it is almost certain that a number of these thrashing machines will be imported for the raiyats if facilities for doing so are given. The machine thrashed about 1 ton of ragi in 40 minutes and broke very little, if any, grain in doing so. The grain is thoroughly separated from the straw and chaff and comes out of a spout on the side of the machine in an almost perfectly clean condition. Any ear heads which have been torn off without being thrashed come out of another spout and should be rethrashed by mixing them with the sheaves as they are fed into the machine. If they are rethrashed separately some of the grain is liable to be broken. Two good pairs of bul-

locks ought to be able to drive this machine. It costs in America $ 102·74 with spare parts equivalent to Rs. 321 and the expenses of bringing it out are about Rs. 64. Any good bullock gear strong enough to stand the draft of, say three or four pairs of bullocks and giving the cylinder of the machine 1,000 revolutions per minute, ought to answer the purpose of driving it.

65. A somewhat larger machine, "The Little Giant," manufactured by the same firm, has been imported for Mr. N. Krishna Iyengar of Oorgahalli, but has not yet been tested. A number of other Indian gentlemen are considering the advisability of purchasing a similar machine.

66. A mowing machine, manufactured by Messrs. Massey Harris of Toronto, Canada, did very satisfactory work in cutting grass on rather rough ground at Sanyasihalli. It costs, landed in Bangalore, about Rs. 135 and one pair of bullocks can work it. A reaping machine, manufactured by the same firm, costing about Rs. 240 and capable of cutting at least 10 acres of ragi in a day, did satisfactory work on the Experimental Farm. To cut ragi with this machine it must be sown by itself and have no other crops such as avare or cholam growing in it. The ragi should also be cut before the heads have drooped so far that they nearly touch the ground. The reaper can be worked by a good pair of bullocks.

67. A chaff-cutter, made by the same firm, costing about Rs. 41, landed in Bangalore, also deserves special mention. It can be easily turned by one cooly and does excellent work. The Department could have sold several of these machines if it had any for sale. One is being imported for Mr. N. Krishna Iyengar.

68. Among the other implements and machines imported this year are a "spring tooth cultivator" and a "lever harrow" both of which have done good work, but as the nuts are liable to get loose on the lever harrow, it is necessary that the cooly using it is a watchful man and tightens the nuts when they get

loose. This harrow is used in sections. Two sections can be easily drawn by one pair of good bullocks. Mr. N. Krishna Iyengar was so pleased with the work of this implement for levelling the ground before sowing ragi and for thinning it afterwards that he got two sections of it through this Department. As labour is getting more expensive and more difficult to get during the harvesting and sowing seasons, the advantage of good agricultural machinery and implements will be more and more apparent. It is necessary, however, to use the utmost care in selecting it. The requirements of India are so different in this line from what is needed elsewhere that the fact of a machine working very satisfactorily, say in America, is no proof that it will work here. A "seed-drill" imported from America gives some proof of this.

DASARA AGRICULTURAL AND INDUSTRIAL EXHIBITION.

69. The Department spent a full month on this Exhibition. But as a special report of that Exhibition has been issued, it is unnecessary for me to do more than simply refer to the matter here.

MYCOLOGY AND ENTOMOLOGY.

70. Dr. Coleman, the Mycologist and Entomologist, arrived in January and began his work at once. He has had some very promising results. But as the work has not yet advanced sufficiently to be reported on, I have not asked him to write a report. I may state, however, that he has been working on a disease of potatoes caused by bacteria and is conducting inoculation experiments with it in the pot-culture house and the laboratory compound. Koleroga is one of several arecanut palm diseases he is studying, and some preliminary experiments in fighting this disease are promising good results. Among the insect pests he has found several parasites. One attacking the kumblihula in Davangere had completely checked for the time being the progress of that pest.

71. A small temporary laboratory has been fitted up for Dr. Coleman's work and a substantial addition will, I hope, be made to that in the very near future.

72. The insect pests and plant diseases have been as troublesome as ever and the field for Dr. Coleman's work is unfortunately almost infinite. I must again impress upon all interested in the work that, if they desire any relief from insect pests and plant diseases, it is absolutely necessary that they notify the Department promptly of the existence of these pests as soon as they appear and to keep a keen look-out for such pests, so that they notice them as soon as they appear. It is always much easier to fight them when they make their first appearance and are confined to small areas than after they have got a firm hold and are spread over a large tract of land.

A. LEHMANN, PH.D.,
Agricultural Chemist.

TABLE I.

Giving the returns of Grains from each of the Ragi Plots.

Plot	Year	Range					
		A lbs.	B lbs.	C lbs.	D lbs.	E lbs.	F lbs.
1	1905 ...	274	149	146	361	246	205
	1906 ...	272¾	122½	101	259	195¼	82½
	1907 ...	275½	166¼	167¼	254¾	198¾	173
2	1905 ...	248	198	172	252	262	218
	1906 ...	281½	88½	89½	218½	205	58½
	1907 ...	294¼	184½	195¼	225¼	233½	180½
3	1905 ...	205	220	139	279	253	173
	1906 ...	201	118¾	103¾	207	156½	84
	1907 ...	237¾	195½	177	221½	242	186¾
4	1905 ...	323	186½	183	249	166	206
	1906 ...	238¼	100¾	104½	155	133¾	106¼
	1907 ...	265¾	206¾	175¼	189¼	208¼	204½
5	1905 ...	362	188	184	174	262	226
	1906 ...	240¼	97	106¾	96	146	133
	1907 ...	212¾	196¾	174	174¼	208¼	220
6	1905 ...	180½	198½	185	199	253	226
	1906 ...	152½	97½	69½	85½	118	139½
	1907 ...	183¼	185½	138½	171½	205½	227½
7	1905 ...	245½	181	185	130	193	231
	1906 ...	165¼	104½	74	79½	129½	176
	1907 ...	161¾	201¼	153¾	147½	179¾	202¾
8	1905 ...	195	195½	192	167	.....	248
	1906 ...	173¾	112½	75½	87½	.....	224
	1907 ...	167	191¼	147	158	.....	256¾
9	1905 ...	201½	202	207	172	.....	241
	1906 ...	156	126	70¼	90¾	.....	232
	1907 ...	139¾	188¾	144½	162¾	.....	250¼
10	1905 ...	175	214	192	178	.....	253
	1906 ...	167½	149½	116½	95½	.....	262
	1907 ...	157½	169	160¾	142½	.....	220¾
11	1905 ...	189	197	168½	.....	.....	116
	1906 ...	151½	142	111	.....	.....	202
	1907 ...	159½	172½	137¾	.....	.....	194¾

TABLE I—*concld.*

Plot	Year	Range					
		A lbs.	B lbs.	C lbs.	D lbs.	E lbs.	F lbs.
12	1905 ...	211	202	178	.....	.....	174
	1906 ...	178¼	147¾	130½	.....	.....	112¼
	1907 ...	148¼	168	145	.....	.....	117
13	1905 ...	252	188	168	.....	.....	151
	1906 ...	185	132	165	.....	.....	103
	1907 ...	117½	154	134¾	.....	.....	106½
14	1905 ...	213	179	153	.....	.....	129½
	1906 ...	180½	126½	163	.....	.....	110
	1907 ...	127¾	153	140	.....	.....	118
15	1905 ...	210½	185	164	.....	.....	133
	1906 ...	180½	142¼	179¾	.....	.....	104½
	1907 ...	123¼	120½	125¼	.....	.....	142½
16	1905 ...	.....	.....	.....	.....	.....	142
	1906 ...	.....	.....	.....	.....	.....	127¼
	1907 ...	.....	.....	.....	.....	.....	178¾
17	1905 ...	100½	137	135	188	.....	206
	1906 ...	125¾	165¾	122	148½	.....	113½
	1907 ...	103¼	111¼	75½	51	.....	161
18	1905 ...	122½	153	106	129	191	169
	1906 ...	111¼	135½	95¾	139	171	121
	1907 ...	95¼	123½	99	87	119¼	143
19	1905 ...	159	152	146	177	141	187
	1906 ...	97½	132¾	91	127	141½	125¼
	1907 ...	115¾	126	89½	82¾	122½	159¼
20	1905 ...	98½	158	142	165	155	201½
	1906 ...	92	104¾	104½	153¼	138	132½
	1907 ...	128½	156½	116	85¾	82¼	164
21	1905 ...	.....	.....	.....	149	154	154
	1906 ...	.....	.....	.....	123	136½	143¾
	1907 ...	.....	.....	.....	82	92½	136¾
22	1905 ...	.....	.....	.....	.....	.....	109
	1906 ...	.....	.....	.....	.....	.....	152
	1907 ...	.....	.....	.....	.....	.....	74¾

TABLE II.

Giving the returns of Total Crops from each of the Ragi Plots.

Plot	Year	Range					
		A' lbs.	B lbs.	C lbs.	D lbs.	E lbs.	F lbs.
1	1905 ...	1,034	429	440	1,116	825	560
	1906 ...	764	276	240	664	558	236
	1907 ...	758	452	468	708	622	476
2	1905 ...	1,028	518	449	870	887	637
	1906 ...	710	202	204	556	550	174
	1907 ...	812	470	486	620	650	520
3	1905 ...	837	579	466	860	773	501
	1906 ...	516	274	232	570	430	240
	1907 ...	630	518	478	640	646	516
4	1905 ...	1,083	509	453	684	684	628
	1906 ...	572	230	236	400	326	294
	1907 ...	710	494	474	536	590	532
5	1905 ...	1,050	496	540	513	652	688
	1906 ...	564	226	254	234	364	354
	1907 ...	618	526	510	506	584	580
6	1905 ...	742	541	548	563	645	655
	1906 ...	350	216	158	196	288	386
	1907 ...	522	490	390	500	554	586
7	1905 ...	515	504	499	371	670	798
	1906 ...	356	238	170	158	316	480
	1907 ...	470	504	394	454	492	592
8	1905 ...	504	560	557	432	.....	940
	1906 ...	378	254	170	190	.....	596
	1907 ...	444	510	400	438	.....	726
9	1905 ...	511	527	510	425	.....	1,044
	1906 ...	336	286	166	206	.....	604
	1907 ...	394	494	378	420	.....	710
10	1905 ...	483	571	522	448	.....	994
	1906 ...	362	344	268	222	.....	656
	1907 ...	430	512	454	412	.....	652

TABLE II—*concld.*

Plot	Year	Range					
		A lbs.	B lbs.	C lbs.	D lbs.	E lbs.	F lbs.
11	1905 ...	551	519½	484	.....	.....	308
	1906 ...	322	328	240	.....	.....	574
	1907 ...	418	484	393	.....	.....	602
12	1905 ...	660	518	498	.....	.....	407
	1906 ..	402	332	288	.....	.....	286
	1907 ...	380	478	434	.....	.....	342
13	1905 ...	584	532	508	.....	.....	371
	1906 ...	414	312	366	.....	.....	254
	1907 ...	334	460	416	.....	.....	300
14	1905 ...	560	474	485	.....	.....	362
	1906 ...	404	298	366	.....	.....	272
	1907 ...	348	446	418	.....	.....	342
15	1905 ...	568	490	539	.....	.....	406
	1906 ...	408	336	416	.....	.....	266
	1907 ...	390	384	392	.....	.....	392
16	1905 ...	.....	.....	.....	.....	.....	469
	1906 ...	.....	.....	.....	.....	.....	316
	1907 ...	.....	.....	.....	.....	.....	458
17	1905 ...	288	338	244	420	.....	562
	1906 ...	316	388	270	354	.....	294
	1907 ...	296	298	222	158	.....	474
18	1905 ...	345	424	287	371	474	441
	1906 ...	238	314	228	318	402	310
	1907 ...	262	332	284	272	396	430
19	1905 ...	370	434	346	340	417	525
	1906 ...	228	302	216	280	322	316
	1907 ...	310	376	270	250	394	484
20	1905 ...	291⅓	426	407	448	327	506
	1906 ...	206	240	240	360	304	324
	1907 ...	338	436	334	266	252	486
21	1905 ...	.....	.....	.....	329	312	448
	1906 ...	.....	.....	.....	286	312	350
	1907 ...	.....	.....	.....	242	286	422
22	1905 ...	.....	.....	.....	.....	.....	371
	1906 ...	.....	.....	.....	.....	.....	364
	1907 ...	.....	.....	.....	.....	.....	258

TABLE III.

Giving returns of Grain from each of the Ragi Plots calculated as percentages of the average for each year.

Plot	Year	Range					
		A	B	C	D	E	F
1	1905	146·97	79·92	78·31	193·63	131·95	109·96
	1906	193·78	87·03	71·76	184·01	138·72	58·61
	1907	171·26	103·35	103·96	158·36	123·55	107·54
	Total Variation ...	46·81	23·43	32·20	35·27	15·17	51·35
	Variation of 1905 and 1907	24·29	23·43	25·65	35·27	8·40	2·42
2	1905	133·02	106·20	92·26	135·17	140·53	116·93
	1906	200·00	62·87	63·59	155·24	145·65	41·56
	1907	182·91	114·69	121·37	140·02	145·15	112·20
	Total Variation ...	66·98	51·82	57·78	20·07	5·12	75·37
	Variation of 1905 and 1907	49·89	8·49	29·11	4·85	4·62	4·73
3	1905	109·96	118·00	74·56	149·65	135·70	92·79
	1906	142·81	84·37	73·71	147·07	111·19	59·68
	1907	147·79	121·53	110·03	137·69	150·43	116·09
	Total Variation ...	37·83	37·16	36·32	11·96	39·24	56·41
	Variation of 1905 and 1907	37·83	3·53	35·47	11·96	14·73	23·30
4	1905	173·25	100·00	98·16	133·56	89·03	110·49
	1906	169·27	71·58	74·24	110·12	95·03	75·49
	1907	165·20	128·52	108·94	117·64	129·45	127·12
	Total Variation ...	8·05	56·94	34·70	23·44	40·42	51·63
	Variation of 1905 and 1907	8·05	28·52	10·78	15·92	40·42	16·63
5	1905	194·17	184·00	98·69	93·33	140·53	121·22
	1906	170·69	68·92	75·84	68·21	103·73	94·49
	1907	132·25	122·30	108·16	108·32	129·45	136·76
	Total Variation ...	61·92	115·08	32·32	40·11	36·80	42·27
	Variation of 1905 and 1907	61·92	61·70	9·47	14·99	11·08	15·54
6	1905	96·82	106·47	99·23	106·74	135·70	121·22
	1906	108·35	69·27	49·38	60·74	83·84	99·11
	1907	113·91	115·31	86·09	106·61	127·74	141·42
	Total Variation ...	17·09	46·04	49·85	46·00	51·86	42·31
	Variation of 1905 and 1907	17·09	8·84	13·14	0·13	7·96	20·20
7	1905	131·68	97·08	99·23	69·73	103·52	123·90
	1906	117·41	74·24	52·57	56·48	92·01	125·04
	1907	100·55	125·10	95·57	91·69	111·74	126·03
	Total Variation ...	31·13	50·86	46·66	35·21	19·73	2·13
	Variation of 1905 and 1907	31·13	28·02	3·66	21·96	8·22	2·13
8	1905	104·59	104·86	102·98	89·58	.....	133·02
	1906	123·45	79·93	53·64	62·16	.....	159·15
	1907	103·81	118·88	91·38	98·22	.....	159·60
	Total Variation ...	19·64	38·95	49·34	36·06	.....	26·58
	Variation of 1905 and 1907	0·78	14·02	11·60	8·64	.....	26·58

TABLE III—*contd.*

Plot	Year	Range					
		A	B	C	D	E	F
9	1905	108·08	108·35	111·03	92·26	.....	129·27
	1906	110·83	89·52	49·91	64·48	.....	164·83
	1907	86·87	117·33	89·82	101·17	.....	155·56
	Total Variation ...	23·96	27·81	61·12	36·69	.....	35·56
	Variation of 1905 and 1907	21·21	8·98	21·21	8·91	.....	26·29
10	1905	93·87	114·78	102·98	95·47	.....	135·70
	1906	118·82	104·22	82·77	67·67	.....	186·14
	1907	97·91	105·05	99·93	88·58	.....	137·22
	Total Variation ...	24·95	10·56	20·21	27·80	.....	50·44
	Variation of 1905 and 1907	4·04	9·73	3.05	6·89	.....	1·52
11	1905	101·38	105·67	90·38	.....	.....	62·22
	1906	107·64	100·89	78·86	.....	.....	143·52
	1907	99·15	107·23	85·63	.....	.....	121·06
	Total Variation ...	8·49	6·34	11·52	.....	.....	81·30
	Variation of 1905 and 1907	2·23	1·56	4·75	.....	.....	58·84
12	1905	113·18	104·35	96·01	.....	.....	93·33
	1906	126·64	104·97	92·72	.....	.....	79·75
	1907	92·16	104·43	90·14	.....	.....	72·73
	Total Variation ...	34·48	0·62	5·87	.....	.....	20·60
	Variation of 1905 and 1907	21·02	0·08	5·87	.....	.....	20·60
13	1905	135·17	100·87	90·11	.....	.....	80·99
	1906	131·44	93·78	117·23	.....	.....	73·18
	1907	73·04	95·73	83·76	.....	.....	66·20
	Total Variation ..	62·13	7·09	33·47	.....	.....	14·79
	Variation of 1905 and 1907	62·13	5·14	6·35	.....	.....	14·79
14	1905	114·25	96·00	82·07	.....	.....	69·46
	1906	128·24	89·87	115·81	.....	.....	78·15
	1907	79·41	95·11	87·03	.....	.....	73·35
	Total Variation ...	48·83	6·13	33·74	.....	.....	8·69
	Variation of 1905 and 1907	34·84	0·89	4·96	.....	.....	3·89
15	1905	112·91	99·23	87·97	.....	.....	71·34
	1906	128·24	101·06	127·71	.....	.....	74·24
	1907	76·61	74·91	77·86	.....	.....	88·58
	Total Variation ...	51·63	26·15	49·85	.....	.....	17·24
	Variation of 1905 and 1907	36·30	24.32	10·11	.....	.....	17·24
16	1905	.....	.....	.....	.....	.....	76·17
	1906	.....	.....	.....	.....	.....	90·41
	1907	.....	.....	.....	.....	.....	111·12
	Total Variation ...	.....	.....	.....	.....	.....	34·95
	Variation of 1905 and 1907	.....	.....	.....	.....	.....	34·95

TABLE III—*concld.*

Plot	Year	Range					
		A	B	C	D	E	F
17	1905	53·91	73·48	72·41	100·84	.....	110·49
	1906	89·34	117·76	86·68	105·51	.....	80·64
	1907	64·18	69·16	46·93	31·70	.....	100·08
	Total Variation ...	35·43	48·60	39·75	73·81	.....	29·85
	Variation of 1905 and 1907	10·27	4·32	25·48	69·14	.....	10·41
18	1905	65·71	82·07	56·86	69·19	102·44	90·65
	1906	79·04	96·27	67·83	98·75	121·49	85·97
	1907	59·21	76·77	61·54	54·08	74·13	88·89
	Total Variation ...	19·83	19·50	10·97	44·67	47·36	4·68
	Variation of 1905 and 1907	6·50	5·30	4·68	15·11	28·31	1·76
19	1905	85·28	81·52	78·31	94·40	75·63	100·30
	1906	69·27	94·32	64·65	90·23	100·53	88·99
	1907	71·95	78·32	55·63	51·44	76·15	98·99
	Total Variation ...	16·01	16·00	22·68	42·96	24·90	11·31
	Variation of 1905 and 1907	13·33	3·20	22·68	42·96	0·52	1·31
20	1905	52·83	84·75	76·17	88·50	83·14	108·08
	1906	65·36	74·42	74·25	109·85	98·04	94·14
	1907	79·88	97·28	72·11	53·30	51·13	101·95
	Total Variation ...	27·05	22·86	4·06	56·55	46·91	13·94
	Variation of 1905 and 1907	27·05	12·53	4·06	35·20	32·01	6·13
21	1905	.....	.....	.....	.....	82·60	82·60
	1906	.....	.....	.....	.....	96·98	102·13
	1907	.....	.....	.....	.....	57·50	85·01
	Total Variation ...	.....	.....	... ..	.....	39·48	19·53
	Variation of 1905 and 1907	.....	.....	.....	.....	25·10	2·41
22	1905	.....	.....	.....	.....	.....	58·46
	1906	.....	.....	.....	.....	.....	107·99
	1907	.....	.....	.....	.....	.....	46·46
	Total Variation ...	.....	.....	.....	.....	.. ...	61·53
	Variation of 1905 and 1907	.....	.....	.....	.....	.....	12·00

TABLE IV.

Giving the Total Crops from each of the Ragi Plots calculated as percentages of the average for each year.

1	1905	191·76	79·56	81·60	206·97	153·00	103·86
	1906	230·13	83·14	72·29	200·02	168·08	71·09
	1907	167·09	99·64	103·16	156·07	137·11	104·93
	Total Variation ...	63·04	20·08	30·87	50·90	30·97	33·84
	Variation of 1905 and 1907	24·67	20·08	21·56	50·90	15·89	1·07

TABLE IV—*contd.*

Plot	Year	Range					
		A	B	C	D	E	F
2	1905	190·65	96·07	83·27	161·35	164·50	118·14
	1906	213·87	60·85	61·45	167·48	165·68	52·41
	1907	178·99	103·61	107·13	136·67	143·28	114·63
	Total Variation ...	34·88	42·76	45·68	30·81	22·40	65·73
	Variation of 1905 and 1907	11·66	7·54	23·86	24·68	21·22	3·51
3	1905	155·23	107·38	86·42	159·50	143·36	93·47
	1906	155·43	82·54	69·89	171·70	129·53	72·29
	1907	138·88	114·19	105·26	141·07	142·40	113·75
	Total Variation ...	16·55	31·65	35·37	30·63	13·83	41·46
	Variation of 1905 and 1907	16·35	6·81	18·84	18·43	0·96	20·28
4	1905	200·85	94·40	84·01	126·85	126·85	116·47
	1906	172·30	69·28	71·09	120·49	98·20	88·56
	1907	156·51	108·89	104·49	118·15	130·06	117·27
	Total Variation ...	44·34	39·61	33·40	8·70	31·86	28·71
	Variation of 1905 and 1907	44·34	14·49	20·48	8·70	3·21	0·80
5	1905	194·73	91·99	100·15	95·14	120·92	127·60
	1906	169·90	68·08	76·51	70·49	109·65	106·63
	1907	136·23	115·95	112·42	111·54	128·73	127·85
	Total Variation ...	58·50	47·87	35·91	41·05	19·08	21·22
	Variation of 1905 and 1907	58·50	23·96	12·27	16·40	7·81	0·25
6	1905	137·61	100·33	101·63	104·41	119·62	121·48
	1906	105·43	65·06	47·59	59·04	86·75	116·27
	1907	115·07	108·01	85·97	110·22	122·12	129·18
	Total Variation ...	32·18	42·95	54·04	51·18	35·37	12·91
	Variation of 1905 and 1907	22·54	7·68	15·66	5·81	2·50	7·70
7	1905	95·51	93·47	92·54	68·81	124·26	148·00
	1906	107·24	71·69	51·21	47·59	95·19	144·59
	1907	103·60	111·10	86·85	100·08	108·45	130·50
	Total Variation ...	11·73	39·41	41·33	52·49	29·07	17·50
	Variation of 1905 and 1907	8·09	17·63	5·69	31·27	15·81	17·50
8	1905	93·47	103·86	103·30	80·12	.....	174·33
	1906	113·86	76·51	51·21	57·23	.....	179·53
	1907	97·87	112·42	88·17	96·55	.....	160·04
	Total Variation ...	20·39	35·91	52·09	39·32	.....	19·49
	Variation of 1905 and 1907	4·40	8·56	15·13	16·43	.....	14·29
9	1905	94·77	97·74	94·58	78·82	... .	193·62
	1906	101·21	86·15	50·00	62·05	.....	181·94
	1907	86·85	102·90	83·32	92·58	.....	156·51
	Total Variation ...	14·36	16·75	44·58	30·53	.....	37·11
	Variation of 1905 and 1907	7·92	5·16	11·26	13·76	.....	37·11

TABLE IV—*contd.*

Plot	Year	Range					
		A	B	C	D	E	F
10	1905	89·97	105·90	96·81	83·09	.....	184·35
	1906	109·04	103·62	80·73	66·87	.....	197·61
	1907	94·79	112·86	100·08	90·82	.....	143·72
	Total Variation ...	19·07	9·24	19·35	23·95	.....	53·89
	Variation of 1905 and 1907	4·82	6·96	3·27	7·73	.....	40·63
11	1905	102·19	96·35	89·76	.....	.....	57·12
	1906	97·00	98·80	72·29	.....	.....	172·91
	1907	92·14	106·69	86·41	.....	.....	132·70
	Total Variation ...	10·05	10·34	17·47	.....	.....	115·79
	Variation of 1905 and 1907	10·05	10·34	3·35	.....	.....	75·58
12	1905	122·40	96·07	92·36	.....	.....	75·48
	1906	121·09	100·01	86·75	.....	.....	86·15
	1907	83·77	105·37	95·67	.....	.....	75·39
	Total Variation ...	38·63	9·30	8·92	.....	.....	10·76
	Variation of 1905 and 1907	38·63	9·30	3·31	.....	.....	0·09
13	1905	108·31	98·66	94·21	.....	.....	68·81
	1906	124·71	93·98	110·25	.....	.....	76·51
	1907	73·63	101·40	91·70	.....	.....	66·13
	Total Variation ...	51·08	7·42	18·55	.....	.....	10·38
	Variation of 1905 and 1907	34·68	2·74	2·51	.....	.....	2·68
14	1905	103·86	87·91	89·95	.....	.....	67·14
	1906	121·69	89·77	110·25	.....	.....	81·93
	1907	76·71	98·31	92·14	.....	.....	75·39
	Total Variation ...	44·98	10·40	20·30	.....	.....	14·79
	Variation of 1905 and 1907	27·15	10·40	2·19	.....	.....	8·25
15	1905	105·34	90·88	99·96	.....	.....	75·30
	1906	122·90	101·21	125·31	.....		80·13
	1907	85·97	84·65	86·41	.....	.	86·41
	Total Variation ...	36·93	16·56	38·90	.....	.....	11·11
	Variation of 1905 and 1907	19·37	6·23	13·55	.....	.	11·11
16	1905	.....	.....	.....	.....	.....	86·98
	1906	.....	.....	.....	.....	.....	95·19
	1907	.....	.....	.....	.....	.....	100·96
	Total Variation ...	.....	.....	.....	.....	.....	13·98
	Variation of 1905 and 1907	.....	.....	.....	.....	.....	13·98
17	1905	53·41	62·69	45·25	77·89	.....	104·23
	1906	95·19	116·87	81·33	106·63	.....	88·56
	1907	65·25	65·69	48·94	34·82	.....	104·49
	Total Variation ...	41·78	54·18	36·08	71·81	.....	15·93
	Variation of 1905 and 1907	11·84	3·00	3·69	43·07	.....	0·26

TABLE IV—*concld.*

Plot	Year	Range					
		A	B	C	D	E	F
18	1905	63·98	78·63	53·23	68·81	77·34	81·79
	1906	71·69	94·59	68·68	95·79	121·09	93·38
	1907	57·75	73·18	62·60	59·96	87·29	94·57
	Total Variation ...	13·94	21·41	15·45	35·83	43·75	12·78
	Variation of 1905 and 1907	6·23	5·45	9·37	8·85	9·95	12·78
19	1905	68·62	80·49	64·17	63·06	77·34	97·37
	1906	68·68	90·97	65·07	84·34	96·99	95·19
	1907	68·34	82·88	59·52	55·11	86·85	106·69
	Total Variation ...	0·34	10·48	5·55	29·23	19·65	11·50
	Variation of 1905 and 1907	0·28	2·39	4·65	7·95	9·51	9·32
20	1905	54·06	79·01	75·48	83·09	60·65	93·47
	1906	62·05	72·29	72·29	108·44	91·57	97·60
	1907	74·51	96·11	73·62	58·64	55·55	107·13
	Total Variation ...	20·45	23·82	3·19	49·80	36·02	13·66
	Variation of 1905 and 1907	20·45	17·10	1·86	24·45	5·10	13·66
21	1905	.....	....	.....	61·02	57·86	83·09
	1906	.....	.....	.....	86·15	93·98	105·43
	1907	.....	.....	.....	53·34	63·04	93·02
	Total Variation ...	.....	.....	.....	32·81	36·12	22·34
	Variation of 1905 and 1907	.....	.....	.....	7·68	5·18	9·93
22	1905	.....	.....	.....	.....	.....	68·81
	1906	.....	.....	.....	.....	.....	109·65
	1907	.....	.....	.....	.....	.....	56·87
	Total Variation ...	.....	.....	.....	.....	.....	52·78
	Variation of 1905 and 1907	.....	.....	.....	.....	.....	11·94

TABLE V.

Standardisation of Ragi Plots, Season 1905 and 1907.

Plot	Range A			Range B			Range C			Range D			Range E			Range F		
	Yield %		Experiment	Yield %		Experiment	Yield %		Experiment	Yield %		Experiment	Yield %		Experiment	Yield %		Experiment
	Grain	Total Crop		Grain	Total Crop		Grain	Total Crop		Grain	Total Crop		Grain	Total Crop		Grain	Total Crop	
1	...	...	...	...	...	...	...	...	...	...	...	...	128	145	25	109	104	30
2	...	...	...	110	100	6	...	...	...	...	...	...	143	154	19	115	116	29
3	...	...	...	119	111	1	...	...	...	...	...	...	143	143	20	...	...	...
4	...	...	...	...	...	...	...	...	...	126	122	26	...	...	...	119	117	28
5	...	...	...	...	...	...	103	106	35	101	103	36	135	125	21	129	127	24
6	...	...	...	111	104	4	92	94	43	107	107	32	131	121	23	131	125	22
7	...	...	...	...	...	...	97	90	40	..	...	...	107	116	31	125	139	27
8	104	96	9	112	109	3	96	97	39	94	88	41	...	...	...	...	...	..
9	...	...	...	113	100	2	...	...	...	...	...	...	...	...	...	...	...	...
10	91	92	13	110	104	5	101	98	37	...	...	...	...	...	...	...	...	...
11	100	97	10	106	102	7	88	88	45	...	...	...	...	...	...	...	...	...
12	...	...	...	104	108	8	93	94	42	...	...	...	...	...	...	...	...	...
13	...	...	...	98	100	11	87	93	46	...	...	...	...	...	...	83	75	50
14	...	...	...	96	93	12	85	91	47	...	...	...	...	...	...	74	67	54
15	...	...	...	...	...	...	83	93	49	...	...	...	...	...	...	71	71	55
16	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	80	81	51
17	59	59	58	71	64	18	...	...	...	...	...	...	...	...	...	...	...	...
18	62	61	57	79	76	16	...	...	...	...	...	...	...	...	..	105	104	33
19	78	68	17	80	82	15	59	58	59	62	64	56	...	...	...	90	88	44
20	...	...	...	91	88	14	...	...	...	...	...	...	76	76	52	100	102	38
21	...	...	...	...	...	...	74	75	53	...	...	...	...	...	...	105	100	34
22	...	...	...	...	...	..	...	...	...	...	...	...	...	...	...	84	88	48
							...	...	...	...	...	...	...	...	...	52	62	60

TABLE VI.

Yield of Paddy.—Range B.

Plot	1905-06		1906		1907		1907-08	
	Total Crop	Grain	Total Crop	Grain	Total Crop	Grain	Total Crop	Grain
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	1,170	354	1,534	434	726	334	436	165
2	937½	330	1,483	421	682	318	372	138¾
3	860	319	1,268	404	616	282	358	124
4	1,068½	379½	1,429	379	660	292	384	137¼
5	918	338	1,358	318	632	294	404	148½
6	823½	349	1,259	289	640	286	426	152½
7	850½	334½	1,472	342	634	282	432	153½
8	545	256	1,066	258	642	290	378	125
9	619	214	1,127	249	596	276	334	107
10	671	260	1,169	259	636	286	304	97½
11	674	254	1,064	236	656	290	280	82¼
12	614	236	1,126	258	550	220	258	78½
13	621	259	1,130	250	576	258	260	86
14	1,038	285	1,121½	289½	572	254	282	90
15	868	244	1,160	259	612	260	288	97
16	702	221	1,098	225	668	264	310	96
17	666	221	1,028	208	638	250	278	75

TABLE VII.

Yield of Paddy.—Range C.

	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	1,082	313	786	233	650	242	394	152½
2	944	295	890	284	686	274	398	149
3	874	297½	768	260	648	278	360	138
4	940	303½	766	252	724	304	342	127
5	889	293½	804	284	848	362	348	131½
6	925½	303	904	316	900	370	386	149
7	875	268½	776	252	740	298	366	136
8	745	251½	700	226	828	380	408	157
9	753½	240	638	207	722	333½	314	125
10	827	234	644	225	676	296	300	117
11	811	233	574	198	676	287½	304	117¼
12	558	204	574	198	628	283½	288	113
13	542	204	594	216	624	254½	254	95¾
14	598	301	604	221	604	250	238	79
15	693	207	612	213	632	261	250	88½
16	686	215	666	218	654	248	230	80
17	652	199	516	171	562	207	218	72¾

TABLE VIII.

Composition of Mysore Coffee.

Number	Price realized	Specific gravity	Comparative rank in		Nitrogen	Moisture	Loss on ignition	Fe_2O_3 and Al_2O_3	Lime CaO	Phosphoric acid P_2O_5	Magnesia MgO	Soda Na_2O	Potash K_2O	Ether extract	Crude fibre
			Specific gravity	Price											
127 ...	114	1·281	1	1	2·045	9·09	91·90	·065	·14	·38	·31	·175	1·915	13·14	19·84
128 ...	112	1·270	2	2	2·195	.....	91·74	·125	·15	·395	·35	·190	2·01	.....	.....
105 ...	95	1·259	6	3	2·08	9·11	91·48	·059	·145	·405	·355	.....	2·01	13·81	19·84
101 ...	92	1·263	3	4	2·295	8·55	90·19	·030	·160	·3650	·34	.....	1·925	11·80	19·42
102 ...	88	1·262	4	5	2·25	9·81	91·89	·100	·175	·395	·41	·275	2·085	12·20	18·99
100 ...	74	1·262	5	6	2·14	7·66	90·15	·050	·160	·177	·345	.....	1·925	13·15	19·43
107 ...	62	1·237	11	7	2·335	8·74	90·65	·046	·14	·445	·365	.....	1·885	12·09	19·90
83 ...	60	1·241	10	8	2·44	7·91	91·59	·050	·165	·42	·360	.....	1·54	11·60	20·75
129 ...	57	1·251	9	9	2·35	9·76	92·22	·060	·190	·39	·37	·205	2·19	10·60	19·64
84 ...	55	1·254	8	10	2·25	7·63	92·16	·055	·175	·435	·39	.....	1·61	12·25	20·68
130 ...	50	1·257	7	11	2·285	7·97	92·64	·055	·160	·370	·36	·095	2·025	12·06	20·44
106 ...	49	1·233	13	12	2·45	8·06	90·68	·046	·180	·420	·35	.....	2·52	9·87	20·59
85 ...	47	1·234	12	13	2·485	.....	91·55	·060	·210	·440	·36	.....	2·205	.....	.....

TABLE IX.

Composition of Coorg Coffee.

133 ...	68	1·258	1	1	2·485	10·37	91·44	·05	·18	·42	·37	.....	2·305	10·30	19·63
132 ...	62	1·252	2	2	2·360	10·29	91·60	·03	·15	·415	·335	·155	2·165	11·36	19·68
131 ...	53	1·239	3	3	2·495	.....	91·33	·05	·17	·425	·365	·150	2·265	.....	.....
86 ...	53	1·202	8	4	2·455	.....	91·50	·05	·185	·430	·365	.....	2·135	.....	.....
108 ...	52	1·231	5	5	2·37	9·84	89·54	·085	·17	·405	·355	·170	2·235	11·04	19·44
87 ...	50	1·228	6	6	2·455	7·33	91·75	·05	·185	·445	·380	.....	2·135	11·15	22·15
110 ...	47	1·236	4	7	2·480	9·74	90·47	·085	·165	·44	·380	.....	2·275	10·20	18·85
109 ...	47	1·217	7	8	2·360	10·19	88·78	·04	·170	·405	·360	·16	2·275	10·43	19·14
88 ..	45	1·175	9	9	2·430	6·91	91·75	·05	·215	·46	·365	.....	2·335	10·40	21·70

TABLE X.

Composition of Nilgiris Coffee.

Number	Price realized	Specific gravity	Comparative rank in		Nitrogen	Moisture	Loss on ignition	Fe_2O_3 and Al_2O_3	Lime Cao	Phosphoric Acid P_2O_5	Magnesia Mgo	Soda Na_2O	Potash K_2O	Ether extract	Crude fibre
			Specific gravity	Price											
124 ...	68	1·278	1	1	2·06	8·36	92·22	·13	·16	·405	·385	·235	1·890	14·16	20·32
125 ...	58	1·275	3	2	2·05	7·96	92·83	·085	·14	·400	·350	·315	1·945	14·83	19·76
123 ...	60	1·273	2	3	2·16	10·27	90·45	·080	·19	·435	·37	·090	2·03	12·51	19·95
94 ...	53	1·255	5	4	2·03	7·52	91·73	·04	·18	·395	·295	.....	2·07	13·65	18·35
122 ...	55	1·251	4	5	2·06	9·34	90·08	·24	·18	·420	·350	·05	1·96	12·83	19·37
95 ...	43	1·207	6	6	2·28	6·83	91·29	·08	·26	·415	·375	.....	2·34	11·15	19·12

TABLE XI.

Composition of Naidoobatum Coffee.

104 ...	85	1·277	1	1	2·155	9·42	90·18	·04	·175	·38	·36	.....	2·035	12·90	19·47
103 ...	68	1·277	2	2	2·135	8·92	91·25	·035	·170	.....	.....	.....	.....	13·44	18·38
89 ...	51	1·226	3	3	2·310	7·09	90·09	·075	·185	·43	·365	.....	2·17	11·69	21·12
90 ...	47	1·218	4	4	2·355	5·80	91·74	·07	·200	·43	·350	.....	2·27	11·67	19·95

TABLE XII.

Composition of Nelliampathy Coffee.

91 ...	61	1·246	1	1	2·205	7·20	92·25	·075	·19	·42	·365	.....	2·04	12·25	20·16
93 ...	52	1·245	2	2	2·290	7·66	91·54	·110	·19	·43	·235	.....	2·07	12·90	19·33
92 ...	49	1·212	3	3	2·270	6·87	91·41	·100	·19	·425	·280	.....	2·07	11·76	20·83

TABLE XIII.

Composition of Costarica Coffee.

Number	Price realized	Specific gravity	Comparative rank in		Nitrogen	Moisture	Loss on ignition	Fe_2O_3 and Al_2O_3	Lime Cao	Phosphoric acid P_2O_5	Magnesia MgO	Soda Na_2O	Potash K_2O	Ether extract	Crude fibre
			Specific gravity	Price											
97 ...	75	1·220	4	1	2·02	8·58	90·95	·065	·180	·41	·340	.....	1·98	14·99	19·43
114 ...	70	1·260	1	2	1·97	9·66	90·74	·036	·125	·41	·320	·17	2·00	14·39	16·85
115 ...	64	1·260	2	3	1·98	8·87	91·39	·040	·120	·385	·350	·275	1·96	14·91	17·87
96 ...	60	1·260	3	4	1·91	9·23	90·35	·070	·200	·375	·370	.....	2·12	13·75	18·15
116 ...	54	1·218	5	5	1·96	11·90	90·20	·055	·120	·375	·340	·280	2·04	13·23	17·82

TABLE XIV.

Composition of Guatemala Coffee.

98	67	1·254	2	1	2·115	8·09	91·20	·07	·16	·385	·395	...	1·98	15·01	19·93
99	55	1·256	1	2	2·00	8·01	90·59	·07	·16	·365	·395	...	2·00	15·05	18·90
118	54	1·254	3	3	2·215	8·88	91·57	·06	·15	·340	·390	·08	1·99	14·11	21·53
117	45	1·235	4	4	2·190	9·80	91·15	·115	·16	·370	·360	·13	2·14	12·62	17·84

TABLE XV.

Composition of Nicaragua Coffee.

111	58	1·256	1	1	2·01	8·61	91·08	·101	·17	·39	·36	...	1·95	13·38	20·07
112	49	1·230	2	2	2·02	8·48	91·71	·065	·155	·37	·36	·27	1·87	13·91	19·51
113	42	1·203	3	3	1·92	8·07	91·05	·056	·175	·39	·36	·29	1·96	12·69	20·21

TABLE XVI.

Composition of Wynaad Coffee.

Number	Price realized	Specific gravity	Comparative rank in		Nitrogen	Moisture	Loss on ignition	Fe_2O_3 Al_2O_3	Lime Cao	Phosphoric acid P_2O_5	Magnesia MgO	Soda Na_2O	Potash K_2O	Ether extract	Crude fibre
			Specific gravity	Price											
120	46	1·248	1	1	2·265	9·94	90·94	·18	·16	·395	·335	·04	2·18	11·47	18·34
119	43	1·159	2	2	2·45	7·47	91·11	·035	·175	·445	·345	·115	2·45	10·44	20·63